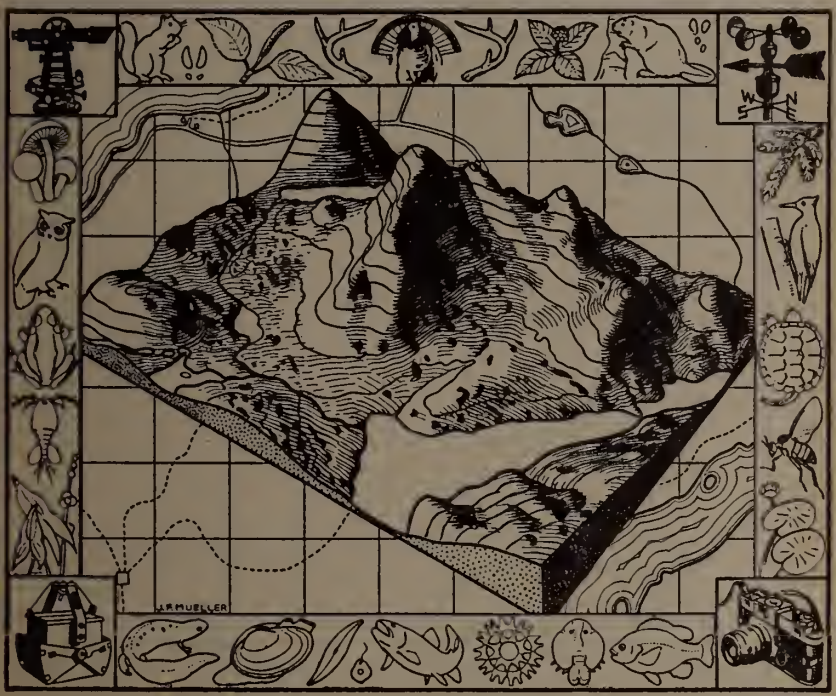
Life History, Ecology and Habits of the Dwarf Sucker, *CATOSTOMUS COMMERSONNII UTAWANA* Mather, at the Huntington Wildlife Station

By

W. A. DENCE



ROOSEVELT WILDLIFE BULLETIN

Volume 8 JUNE, 1948 Number 4

Roosevelt Wildlife Forest Experiment Station

New York State College of Forestry
at Syracuse University, Syracuse, N. Y.

Joseph S. Illick, Dean

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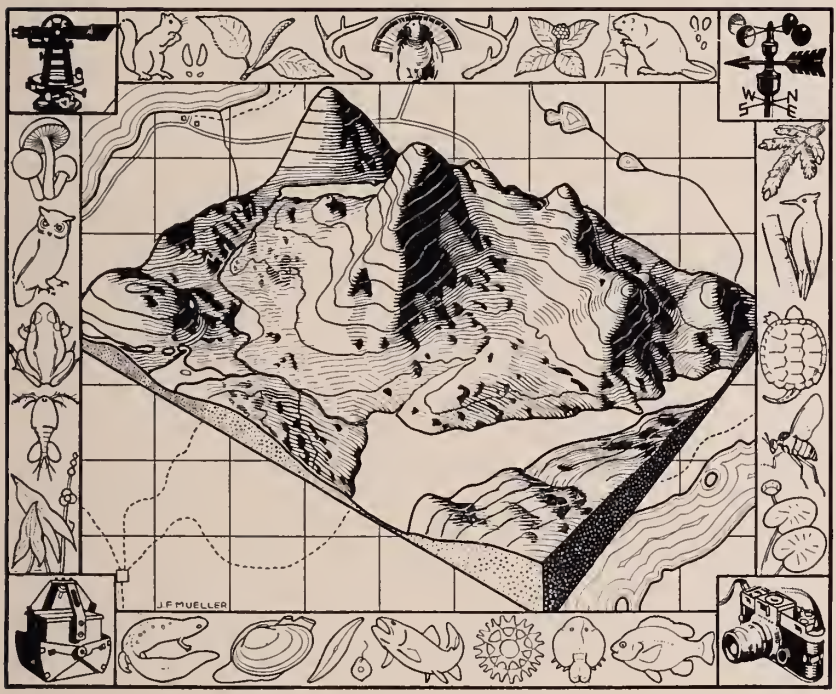

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The *Bulletin* includes papers of a technical or semi-technical nature dealing with various phases of forest wildlife, its management and conservation. The *Service Publication* is intended to be of general and popular interest and attempts to interpret forest wildlife research results and explain the reasons for and methods of their application.

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FIG. 15. A typical pair of dwarf suckers—the upper fish a five-inch male, the lower fish a five and three-fourths-inch female.

FIG. 16. A common sucker and a dwarf sucker taken on same day at Wolf Lake.

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W. A. DENCE

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INTRODUCTION

History. Dwarf suckers, *Catostomus commersonnii utawana* Mather, (Fig.15) appear to be limited in distribution to certain lakes of the Adirondacks in New York State. They were first described by Mather (1890) who discovered them on June 23, 1890 in a small pond in the Blue Mountain Lake region, less than twenty-five miles southwest from the site of the present study. A few days later he found the species* in the Big Moose Lake region. Even with such meagre knowledge of freshwater fishes available at that time, Mather recognized that the fish in question, while quite similar in many respects to the common sucker, *Catostomus commersonnii commersonnii* (Lacépède), obviously was different, particularly as regards its smaller size at maturity (Fig. 16) and its later spawning season. Mather's specific name "utawana" is that of a small lake in the Blue Mountain Lake drainage and was chosen purely for sentimental reasons.

Kendall and Dence ('29) found what obviously was the same species of sucker during the course of their studies on the fishes of the Cranberry Lake region. These writers recognized that Mather was justified in assuming that he had discovered a fish new to Science. They were quite surprised, however, to learn that it had not been included on more recent lists of Adirondack fishes.

Taxonomically the dwarf sucker is so similar to the common sucker that there is insufficient justification for classifying it as a distinct species as did Mather. It is, therefore, being generally recognized and classified as a subspecies of *Catostomus commersonnii* with Mather's specific title "utawana" being relegated to the subspecific position. (Greeley and Greene, '31.)

The Biological Survey party of the New York State Conservation Department found dwarf suckers in the Oswegatchie and Black River systems (Greeley and Greene, '31), in the Upper Hudson watershed (Greeley and Bishop, '32), and in the Raquette River watershed (Greeley, '34). The two subspecies of *Catostomus commersonnii* frequently occur in the same body of water. Greeley (l.c.) found this to be the case at Lake Eaton, while the writer encountered both subspecies at Wolf Lake and elsewhere during the course of this study.

Although the dwarf sucker is believed to be quite generally distributed throughout the Adirondacks, it appears to be limited to the deeper lakes where the summer temperatures do not become excessively high. The writer has never found them where the maxi-

* *Catostomus utawana* according to Mather.

Fig. 17. Lengthwise view of Wolf Lake from point near South Inlet.

Fig. 18. Lengthwise view of Wolf Lake from outlet near north end. North Inlet only a few rods to the left.

Fig. 19. Collecting pool for dwarf suckers, in North Inlet of Wolf Pond. Several hundred suckers congregate in this pool throughout the spawning season.

Fig. 20. Spawning area of dwarf suckers in North Inlet of Wolf Pond. The fish were unable to get beyond the barrier of logs, sticks, etc., shown in the background until freshets removed the débris early in 1944.

mum summer temperature in the lake habitat greatly exceeded that which native brook trout can endure.

At Wolf Lake, on the Huntington Forest, near Newcomb, New York, where the data for this report were obtained, dwarf suckers and brook trout invariably frequented the same habitats, and consequently were usually captured simultaneously in the nets. In fact the task of collecting dwarf suckers without affecting the trout population seemed to be impossible, and resulted in the suspension of netting operations sooner than was originally planned. The trout died very soon after becoming enmeshed in the nets, but the suckers suffered no ill effects unless badly tangled in the meshes.

The meagre knowledge of the dwarf sucker is due in part to its secluded existence because, with the exception of about ten days or two weeks annually during the spawning season, it inhabits deep water. Some individuals in every lake and the entire population of other lakes appear to spend their whole existence in the lake proper, in lieu of adequate spawning facilities in the streams.

Purpose. The study was inaugurated for the following reasons: (1) Preliminary investigations shortly after the property was acquired revealed that the tributary streams of Wolf Lake offered an unusual opportunity to acquire detailed knowledge on a fish subspecies which previously had scarcely been known to Scientists; (2) To study the relations between this and the common sucker; (3) It was part of the general program of research and investigation outlined for the Huntington Wildlife Forest (King, Dence and Webb '41, p. 411).

The Wolf Lake Habitats. Most of the data for this report were obtained from Wolf Lake (Figs. 17 and 18) and its inlets because; (1) there was a great abundance of dwarf suckers in this lake; (2) the physical condition of the inlets with respect to depth, width, and obstructions, such as boulders, logs and stumps, was quite ideal for seining fish; (3) there were two inlets, one at each end, that were being used by spawning fish—an especially desirable feature in connection with migration activities; (4) Wolf Lake was not affected in any manner by exotic species; and (5) the possibility of minimum disturbance from the general public and from other activities on the Forest.

Dwarf suckers were more abundant at Wolf Lake than they were at any of the other lakes on the Forest. In fact there was a greater concentration of suckers here than previously had been encountered by the writer elsewhere in the Adirondacks. Some idea of their abundance may be obtained from the statement that during

the peak of the spawning season on several occasions more than 400 specimens, were landed in a single short haul with the six-foot seine, and hauls of a hundred or more were very common. The large hauls were from what may be called resting pools or retreats—places where the suckers congregated while enroute to or from the spawning beds or where they retreated when disturbed. The data on dwarf suckers at Wolf Lake were supplemented and checked with those from other lakes on the Forest and from adjacent areas.

The inlet at the north end of Wolf Lake (hereinafter called North Inlet) is the larger and most important of the two principal inlets. The upper part of North Inlet was rather precipitous and characterized by many boulders. It, invariably, became dry during periods of scant rainfall. The lower ⅛ mile meandered through rather flat, partially wooded country, part of which was inundated several years ago as the result of a beaver dam in the adjacent outlet. The stream did not exceed eight feet in width during normal water levels, and usually averaged about six feet. The depth of water on the riffles usually varied from a few inches to about a foot during the sucker spawning season—that in the pools from one to two feet. The bottom consisted of small rocks and boulders with considerable coarse sand and gravel. The pools and certain stretches were characterized by coarse sand and gravel. This lower section becomes extremely low in volume of water during droughts but seldom completely dries.

The inlet at the south end of the lake (hereinafter called South Inlet) originates in a small bog less than one-half mile from the lake. It flows through a low ravine and except for a few rods near the lake has a mucky bottom. The part nearest the lake meanders through a former beaver meadow, and this portion was used by the spawning dwarf suckers. It was about three feet wide in this section, and about a foot deep during the spawning season. The cover for this section consisted of speckled alder and pole-size hardwoods. The bottom was mostly of fine and coarse sand with a few small boulders and cobblestones in certain spots. Both streams formed a delta of fine sand upon entering the lake.

Wolf Lake is approximately one mile long and one-fourth mile wide, with its long axis extending in about a north-south direction. It has a total area of 143.74 acres, of which 108.4 acres are ten feet or more in depth. There are two depressions in the lake — one in about the mid-region of the southern portion, with a maximum depth of 45 feet and the other slightly south of the mid-region of the northern portion with a maximum depth of 40 feet. The ridge

between these depressions normally is about 20 feet below the surface of the water.

The bottom on approximately three-fourths of the lake (that beyond the littoral zone) consisted of a deep deposit of soft oozy muck, typical of most Adirondack lakes. In the littoral zone the bottom consisted mostly of sand, gravel and boulders, with the latter particularly conspicuous at the various jutties or points of land. A narrow sand beach occurred at the extreme south end of the lake, and a narrower one at the northern end. Both were important as foraging areas for minnows and other small fishes including the fry of small suckers.

The level of Wolf Lake was raised as much as three or four feet about twenty years ago as the result of beaver activities. This killed a narrow fringe of arbor vitae along both sides and more expansive areas at each end, particularly those adjacent to the two inlet streams that have been used by dwarf suckers for spawning purposes. Beaver did not resume activity at Wolf Lake until this study was completed. A small amount of speckled alder and a few other woody plants at the north end of the lake did attract a small colony in 1946. They erected a dam at the mouth of North Inlet which was sufficient to prevent all but a few dwarf suckers from reaching the spawning grounds.

The trees killed in the flooded zone at the south end of the Lake were removed as a "clean-up" project in the C.C.C. work plan three years prior to the completion of this study. This, seemingly, had an adverse effect on the suitability of the stream as a spawning habitat, because the population decreased decisively in subsequent years. The affected zone at the north end has been reverting to forest and a considerable amount of cover already exists. The spawning dwarf sucker population has steadily increased in this inlet during the course of the study.

Acknowledgments. During the progress of the field work the writer received cooperation and assistance from his colleagues and various other individuals all of which is gratefully acknowledged. Special thanks are due Mr. Oscar W. Oja, Supervisor of the Huntington Forest, particularly for services rendered after regular working hours and on legal holidays when other assistance was unavailable.

FIELD METHODS AND TECHNIQUES

In fulfilling the purpose of the study data were obtained particularly on sex ratios, ages, spawning habits and migration, but incidentally on any other phase of the life history, ecology and habits

that might be forthcoming. Data of this sort are very essential in establishing the ecological and economic relations of the fish with reference to the general biota of the waters on the Huntington Forest, as well as those of the entire Adirondacks and adjacent regions.

Collecting in the Inlets. The dwarf suckers were collected mostly by means of a 4′ x 6′ common sense minnow seine, operated by one man (Fig. 19). A hundred or more individuals were retained in a large bucket of water, and transported to a convenient place nearby for study. The marked fish were put in a similar container and when the batch was completed were released well downstream in uninhabited areas. Collecting was always progressive from the lowermost to the upper pools. Very few dwarf suckers were captured on the riffles — if these did not retreat to the pools of their own volition, they were driven. Once within the pools the suckers were reluctant to leave, so that eventually every individual was collected with the seine.

Much of the success in capturing great numbers of dwarf suckers can be attributed to the fact that the inlets of Wolf Lake were well adapted for seining. The pools were practically free of boulders, brush and other objects that reduce the efficiency of seines, and furthermore there were no inaccessible hiding places.

Marking. The fish were marked by the clipped-fin method. Since only the lower fins could be safely removed and a single fin was to be removed each year, the marking was limited to five years. The program started with the dwarf sucker breeding season of 1938, and was continued without interruption for the specified five-year period. As a matter of fact, recoveries on marked fish were obtained in the 1943, 1944, 1945 and 1946 seasons following the conclusion of the original study.

During the first two years of the study, the dwarf suckers in the two inlets were differentiated by the removal of entirely different fins (right ventral and right pectoral on North Inlet fish, left ventral and left pectoral on South Inlet fish). This was for the purpose of determining, in subsequent years, the extent at which the instinct for returning annually to the identical stream was developed. The same fin (anal) was removed from fish of both streams the third season, but during the last two seasons, the remaining paired fins were removed in their respective order — right ventral or right pectoral fin on South Inlet, left ventral or left pectoral fin on North Inlet.

Unless the fins were clipped very close to the body of the fish,

they invariably regenerated. The extent of regeneration varied with different individuals and particularly in the manner of clipping. Some fins were regenerated almost perfect except for a slight suggestion of unalignment of rays at the point where new growth began. Most regenerated fins were greatly malformed, stubby and with a great amount of adipose tissue. The amputations were made with ordinary fine-pointed dissecting scissors. The dwarf suckers recovered during the second, and each succeeding, year were re-marked in the same manner as those that were being marked for the first time. This means that at the conclusion of the study some fish had been divested of all five lower fins, others from one to four.

The sex of every fish was recorded as was its standard length, special markings (such as scars and deformities) and color phases. Scales for age determinations were removed from a sizable group each season. Some of the scales, taken during the two years following the regular program, were from fish that were definitely known to have spawned six and seven years in succession.

The field party generally consisted of two men (one besides the writer). The latter made all the measurements, determinations and marking, while the helper had complete responsibility of recording the data as dictated and supervised.

Only the standard length (length to end of vertebrae) was taken, and this was recorded to the nearest quarter-inch. At first it was quite difficult and time-consuming to keep the fish in position for measurements. They would not lie flat, or they would slide out of place on the slimy surface of the measuring apparatus. Both of these problems were considerably solved as the study progressed. The sliding was alleviated by placing one or more thicknesses of moistened cheesecloth under the fish. Frequent changes were made as the slime accumulated. Unruly fish could often be quieted with a few gentle strokes of the finger tips along the sides or bellies. This seemed to have a sort of hypnotic effect similar to that described by Hansen ('43) in the case of squirming eels.

In most cases there was no doubt as to the sex because the fish frequently scattered sperm or ova while being prepared for the measurements or during the amputation of fins. Even when this did not occur, sexual dimorphism was sufficiently marked to warrant proper sex determination.

Collecting in Wolf Lake. What happens to the dwarf suckers when they return to Wolf Lake at the completion of the spawning activities? Do those from the North Inlet (or South Inlet) move freely from one part of the lake to the other, or do they remain in

the deep water nearest their chosen spawning stream? Netting activities carried on during August 1941 were planned with the view of obtaining data of this nature.

The catches were made by means of a trammel net which was found to be more efficient than gill nets or other apparatus. Most of the sets were made at right angles to the shore, but others were made parallel to it, or across the neck of a bay. The first-mentioned method proved to be the most valuable especially since the net was long enough to extend from the littoral zone to a point into or beyond the deepest area. The depth at which the greater number were enmeshed in the net was considered *indicative* of the favorite habitat for that particular time of year.

The netting program as originally planned was shortened somewhat to avoid undue losses of brook trout. It is believed, however, that a sufficient number of sets were made to accomplish the intended purpose. Most of the dwarf suckers, captured with the trammel net, were still alive, and these were released after measurements and other data had been secured. Those that were dead had become hopelessly entangled in the meshes of the net. Brook trout suffered far greater losses in this manner than did the suckers. Common suckers and a single bullhead and a few red-bellied sunfish were the only other species taken on these test sets.

The netting operations in Wolf Lake yielded 106 dwarf suckers. Strange as it may seem, *exactly one-half* of these had been marked on one to three occasions during the previous four years' activities. In analyzing the data a few rather significant trends are apparent, but they lack sufficient supportive evidence to warrant definite conclusions.

First of all it should be stated that most of the suckers captured in the net were females, as determined solely from the size of the anal fin — the only reliable external character at that season. Evidently all fish less than seven inches in length were capable of passing through the 1¼-inch meshes of the net. This would exclude most males which, as revealed from the data obtained during the spawning season, do not often exceed that length. The smallest sucker taken in the net was seven inches — the largest was ten and one-half inches, with the majority ranging from seven and one-half to nine inches. Most of the fish were "gilled" in the region immediately anterior to the dorsal fin, which further indicates that those slightly smaller would pass through without becoming snared.

The netting activities revealed that dwarf suckers and common suckers have quite different habitats during the Summer. The former

were seldom found within the littoral zone at that time of year, but the latter were taken more frequently in such places than elsewhere. This was not only true of Wolf Lake, but for the other lakes, as well. Quiet bays, and other places where considerable emergent vegetation prevailed, were particularly attractive to common suckers, but barren insofar as dwarf suckers were concerned. The evidence suggests that common suckers normally do not inhabit shallow water for extended periods, but migrate into such places, especially at night, possibly to obtain food. Dwarf suckers on the other hand apparently obtain sufficient food in the deeper areas without subjecting themselves to possible enemy depredation that unquestionably would occur in shallow water.

The data indicate that dwarf suckers in returning to the same spawning streams each year did so from instinct or the result of some special stimulus rather than the influences caused by environmental conditions, as was formerly suspected. While there was a slight tendency for fish to remain in that part of the lake nearest to their accustomed spawning stream there was no well defined division in the lake between the spawning individuals of the two streams. Thus all the marked suckers recovered in the north half of the lake had spawned in the North Inlet on one to three occasions, but those in the mid-section and southward had representatives of both streams. The distribution in the lake during the summer months appears to be governed more by tolerance, and perhaps food supply, rather than nearness to the spawning grounds. By far the greater number of dwarf suckers spawn in the North Inlet, consequently when they redistribute their numbers subsequent to the spawning season the greatest shift is to the south or towards the area of minimum density.

Instinct appears to be a well developed characteristic of fishes in general and yet it seems quite unusual in the case of dwarf suckers where individuals from two spawning streams on directly opposite ends of the lake meet on a common summer range only to separate in the Spring and enter their respective streams. The few individuals that migrated from one spawning stream to the other in the space of a few hours certainly accomplished an unusual feat, and makes one wonder how such a change of habitat could be performed so quickly. It would seem that these fish reached their destination by means of some special sense or instinct rather than by mere coincidence. Perhaps a combination of factors guided the suckers across the lake to the proximity of the inlet, where a normal response to incoming water was effected.

There is reason to believe that dwarf suckers migrate shoreward

and enter the littoral zone at least ten days (probably much longer) before entering the spawning stream. This was demonstrated very well in Arbutus Lake, on the Huntington Forest. A trammel net was set parallel with the shore at the outer edge of the littoral zone late in the afternoon of May 9, 1942, about ten days before the spawning season. Preliminary examination of the net the following morning revealed that more than fifty dwarf suckers had been captured and many more were ensnared before the net could be removed. This particular site yielded an abundance of common suckers but no dwarfs, in the same net operated during the preceding Summer.

The change of habitat prior to entering tributary spawning streams is characteristic of other fish species, that inhabit deep water during the summer months, i.e. pike-perch, *Stizostedion vitreum vitreum* (Mitchill), in Oneida Lake. Furthermore, there are reasons for believing that many dwarf suckers even follow the example of pike-perch by spawning in shallow water rather than in tributary streams. This seems to be logical because the streams, in general, have inadequate spawning facilities for so many spawning fish within such a short space of time. In Wolf Lake, the available information indicates that possibly only fifty percent of the suckers spawn in the two streams and these utilize about all the suitable space. If the population were much greater, the stream would be physically incapable of accommodating them.

DESCRIPTIONS

Mather's Description. The description of dwarf suckers as rereported by Mather (1890) is based on the type (No. 33918) and is herewith quoted *in toto* because it is not readily available to others. It must be recognized that Mather's description obviously is erroneous and incomplete in many respects and should be valued mostly from the historical viewpoint. Mather listed the species as, "The June Sucker, *Catostomus utawana. Sp. Novo.* (Utawana, name of lake)".

"Body elongate and but little compressed, heaviest at shoulder and tapering to tail, nearly cylindrical; head moderately large, subquadrate, much flattened above; its length in body, four; snout very slightly prominent; mouth nearly terminal, protractile upper lip with two rows of papillae and continuous with the lower; the latter bilobed and strongly papillose; scales crowded anteriorly, but not larger in the lateral line than those below; sixty-seven in lateral line, nine rows above and eight below; lateral line straight, faint, obsolete in spots; length, exclusive of caudal fin, four and one-half inches; eye

in head, four; eye in snout, two; inter-orbital space in head, four. Fins: Dorsal square, inserted in middle of body; rays, one, eleven; its height equals its length. Anal: Five rays, third longest, reaching to base of caudal; this ray is two and one-quarter times the length of the fin. Ventrals inserted under fifth dorsal ray, nine rays, third ray three times the length of the fin. Pectorals: Fifteen rays, reaching nearly to the insertion of dorsal; caudal deeply forked; lobes equal; pharyngeal bones moderate; lower, two teeth enlarged and truncate."

Huntington Forest Dwarf Suckers. The dwarf suckers of the Huntington Forest are herewith being described in considerable detail and with particular emphasis on sexual dimorphism and major differential subspecific characteristics. Investigation may reveal that in the past certain species have been relegated to synonomy as a matter of convenience or because of inadequate descriptions and material. It is hoped that this description of dwarf suckers, therefore, will be useful in determining the taxonomic relations of suckers in other regions.

Kendall and Dence ('29, pp. 281-287) in discussing the family Catostomidae call attention to the need of a revision of the genus *Catostomus*. They state (p. 284) that "We are almost ready to believe that the proper relation of species in the East has not been recognized and that some species have been relegated to synonomy". It was suggested that the solution to the geographical distribution of the genus might be solved on the basis of "at least three postglacial distributional trails leading northward and eastward" with the "Mississippi forms differing from the Atlantic seaboard and the Great Lakes suckers. It is a probable fact some of the more southern forms have geographically overtaken some of the northern and intermediate forms on the distribution trails."

This theory is substantiated in part by the collection of suckers from the Allegheny and Chemung watersheds of New York in which Greeley ('38) found two recognizable forms, although currently regarded as one. He states (p. 63) that an "Examination of large numbers of specimens showed that the sucker population of the area, although currently regarded as conforming to the one subspecies, is a composite of two, recognizable forms. These appear to be split by watershed lines, the Allegheny system having a distinct form, probably representative of the middle Western fauna. The chemung area suckers are like those of other Atlantic coast drainage rivers in having a large mouth and certain differences in snout proportions and other characters which will require further study for exact delimitation."

Sixty-four preserved dwarf suckers, including 46 males and 18 females, collected at various times and more or less at random were used in acquiring data for the following description. Since there was some variation between sexes it was considered best to treat them separately in certain respects especially in regard to comparative measurements. The males used in these compilations averaged 132.9 mm., the females 158.6 mm.

	Males	Females
Head in standard length	3.8	3.7
Head in total length	4.5	4.4
Depth in standard length	5.2	5.0
Depth in total length	6.0	5.8
Snout in head (average)	2.08	2.10
Distance from snout to dorsal fin in standard length	2.0	2.0
Average length longest ray of ventral fin (mm)	19.96	19.59
Average length longest ray of ventral fin (mm)	19.96	19.59
Average length dorsal base (mm)	21.5	23.4
Length dorsal base in standard length	6.1	6.8
Distance from anal fin to lower lobe of caudal in standard length	7.2	6.7
Length caudal peduncle in standard length	11.7	10.5
Depth caudal peduncle in standard length	11.1	10.5
Eye in head	6-7*	6-7
Average length longest ray of pectoral fin (mm)	25.2	28.2
Snout to base ventral in standard length	1.8	1.8
Distance from ventral to anal in standard length average	5.3	4.9

* 6 in small specimens, 7 in large.

Color. Dwarf suckers are rather sombre colored except during the breeding season when they rather suddenly acquire much pigmentation. On May 8, 1942, about a hundred dwarf suckers captured well in-shore in Arbutus Lake had neither pearl organs or the distinctive colorations of breeding fish. While the spawning date was not determined for suckers in this lake that particular season, it undoubtedly began a week or ten days after the above observation (the dates on which spawning began in other waters on the Forest). If the suckers captured in Arbutus Lake on the above-mentioned date spawned that season they must have undergone a seemingly impossible transformation within a brief period for when dwarf suckers enter the spawning streams all but a limited few, and these mostly females, have acquired the typical nuptial features.

This subspecies differs from common suckers in that their breed-

ing colors remain fairly constant during the spawning season, even when removed from water and subjected to various treatments. There were no sudden changes in color such as customarily exhibited by common suckers under similar circumstances. Reighard ('20, p. 6) describes the sudden color changes that common suckers undergo when stimulated by fear coincident with capture. He states that these changes may be accomplished within a few seconds. Hankinson ('19, p. 136) also notes that breeding suckers which he observed in Illinois "lost their intense black markings instantly" on capture. The writer observed that the broad blood-red stripe on the sides of breeding dwarf long-nosed suckers, *Catostomus catostomus nanomyzon* Mather, captured at Cranberry Lake began fading within a few seconds after the fish had been removed from the water, and had disappeared almost completely at the end of fifteen minutes or so. The black pigment, however, was little affected.

The color pattern of breeding dwarf suckers, and particularly that of males, is very distinctive, and makes it possible for one to readily distinguish these fish from associated species in the same stream, even at considerable depths. Perhaps the most conspicuous feature is a light olive-green stripe, three to four scale-rows wide, and extending the entire length of the fish, located in the dorso-lateral region. This stands out in bold contrast by virtue of its position between the darker and somewhat mottled coloration of the dorsal region and a jet-black stripe along each side, which includes the upper half of the lateral line series of scales and, usually, three additional rows. This black stripe extends across the opercles and cheeks to the anteriormost end of the snout.

The sexes of breeding dwarf suckers sometimes are indistinguishable by color alone, but frequently the females are quite uniformly olive-colored above and without any distinctive markings. Occasionally one may detect a faint rosy tint anteriorly along the lateral line. Likewise some individuals have a decidedly bronzy appearance.

A series of five blotches of dark pigmentation occurs on the sides of most individuals. These are rather conspicuous on small highly pigmentated males, but scarcely apparent in females and some of the larger males. One of these blotches covers most of the surface between the operculum and the preoperculum. Another occurs near the base of the caudal fin and the remaining three are quite evenly distributed along the side, but mostly ventral to the lateral line. The pigmentation does not extend dorsally beyond the lateral line series of scales, and includes only two or three rows of scales below the lateral line.

Unusual Color Phase. A few individuals were distinguished from

all others by certain abnormalities such as a curved spine, lack of gill cover, extra fins and the like. These characteristics when considered in connection with the number and position of removed fins made identification certain. There was an occasional fish on the spawning beds each season that could be identified positively from its peculiar coloration when considered with other markings. While we recorded this as "pink" actually the color was more purple than pink. The entire body was affected, but the color was more vivid on the ventral side in the head and thoracic regions. There was also a suggestion of transparency in their appearance. One of these unusually colored suckers first appeared in the 1940-season. It returned the following season, was relieved of another fin and thereafter was captured at the upper end of the spawning area on several successive days. This same fish returned to the spawning stream in 1942—the third consecutive season.

Hansen and Shoemaker ('43, p. 54) describe a peculiar color phase of carp and carp-suckers, due to pigment deficiency, apparently comparable to that of the dwarf suckers described above. They mention that "The skin of the abnormal one has a transparent appearance with a purplish brown color showing through the scales . . . This pigment abnormality is probably genetic rather than a diseased condition since the specimens appear plump and otherwise in good health."

None of the peculiar colored dwarf suckers have been recovered in the lake proper, therefore it is not known whether the lack of pigmentation persists throughout life or is merely a secondary sex character apparent only during the spawning season. The fact that certain individuals exhibit this color phase annually while on the spawning grounds suggests that it is permanent. If that is the case one might expect the coloration to be less vivid outside of the breeding season, because even normally colored individuals lose much of their pigmentation during that period.

Size. Dwarf suckers show considerable variation in size even within the same watershed. This is demonstrated very well in the lakes of the Huntington Forest, all of which are in the same drainage system. The dwarf suckers of Wolf Lake are decidedly smaller than those of Catlin Lake which in turn are slightly smaller than those of Rich Lake. Those in Arbutus Lake are about the size of the Wolf Lake dwarfs.

It appears that Mather (1890) encountered a smaller strain in the Blue Mountain Lake region since he gives the standard length in his description as only four and one-half inches and mentions in the discussion that "it barely reaches five inches". No mention was made

of sexual differences and it is to be assumed that both males and females were included in the computations. If that was the case his fish must have been decidedly smaller than those considered in this report.

Kendall and Dence ('29) give the range in lengths of dwarf suckers in the Cranberry Lake watershed as four to six inches, which is comparable to the Wolf Lake population. Greeley and Greene ('31), Greeley and Bishop ('32) and Greeley ('34) do not mention the sizes included in their collections from the Adirondacks. They specify the size as "small" in each instance.

TABLE 3. SUMMARY OF STANDARD LENGTHS OF DWARF SUCKERS (IN INCHES), SHOWING AVERAGES, MAXIMUM AND MINIMUM BY SEXES

Year	Total No. Fish (Recoveries included)		Average Standard Length		Largest Fish Standard Length		Smallest Fish Standard Length	
	Males	Females	Males	Females	Males	Females	Males	Females
1938.....	1,634	362	5.218	5.958	8.00	8.50	4.00	4.75
1939.....	1,799	825	5.237	6.015	8.00	10.50	3.50	4.50
1940.....	2,074	1,127	5.039	5.878	8.25	11.00	3.25	4.00
1941.....	3,596	662	4.890	5.701	8.25	8.75	3.75	4.25
1942.....	4,165	1,065	5.017	5.623	7.50	8.00	4.00	4.50

A summary of standard lengths of dwarf suckers from Wolf Lake is given in table 3. It will be noted that the females from season to season throughout the five-year period averaged about three-fourths of an inch longer than males. Casual observation in the field, however, gave the false impression of a much greater difference in average lengths of the sexes because there were always a few large females on the beds. The annual influx of a good many small females toward the end of the spawning season, of course, lowered the average size for the year by a considerable amount. While small males likewise, were, more in evidence late in the spawning season, the average was not reduced in the same proportion because of the relatively greater seasonal total.

The difference in size of the sexes becomes apparent, in fishes of the same age-class, early in their existence and certainly before attaining sexual maturity. Female dwarf suckers experiencing their first reproduction period usually are one-half to one inch longer than

males of corresponding sexual status. The discrepancy becomes more pronounced later in life and in a few instances may become as much as two or three inches.

As indicated in table 3 the smallest male taken on the spawning bed was only three and one-fourth inches in standard length, and a considerable number were under four inches. No females were found under four inches and very few less than five inches. An occasional male had attained a length of seven inches or longer, but the general run, as may be concluded from the averages, was between five and six inches. The rate of growth prior to sexual maturity is fairly rapid, but it is very slow thereafter. Males that had been captured on seven successive years were as small as 5¾ and 6¼ inches, indicating that only two or three inches had been added to their length during that period. A 3¾-inch male marked May 21, 1941 and recaptured May 24, 1944 had grown only one and one-fourth inches in the three-year interval. The extremely slow growth of adults complicates the problem of correlating ages with annual growth.

Pearl Organs or Tubercles. Kendall and Dence ('29) in their Cranberry Lake studies observed that one of the differences between dwarf suckers and common suckers was that breeding females of the former were equipped with effective pearl organs which are said to be absent or of rare occurrence in the latter. These authors state (l.c., p. 289) "In most cases these organs were not as fully developed on the females as on the males, but in some cases they were much alike, so that careful examination was necessary to determine the sex from external features. The pearl organs on the scales of the females posterior to the dorsal fin were more pronounced than those on the males. Some of our female specimens have pearl organs on the anal and lower caudal fins as large as those of the males, although it appears that these are exceptional cases."

These observations on dwarf suckers at Cranberry Lake agree very well with those of the writer for this species on the Huntington Forest. The combined data indicate that the two subspecies, while very similar in many respects, are decidely distinct in others. According to most authorities pearl organs characteristically do not occur on breeding female common suckers. Hankinson ('19, p, 436), however, reports that small pearl organs were found on two female common suckers in a collection of spawning suckers captured near Charleston, Illinois. Reighard ('20) gives a detailed description of pearl organs on spawning male common suckers, and concludes his

remarks by stating that "pearl organs do not occur in the female". Likewise Fowler ('12, p. 474) in examining the pearl organs of breeding fish failed to find any on female common sukers.

Pearl organs occur on the scales and fins of both sexes of dwarf suckers. In general, though not always, these structures are weaker and less conspicuous on the females than they are on the males. The scales below the lateral line posterior to the vent and particularly adjacent to the base of the anal fin, are thicker and more heavily studded with pearl organs on the females than on the males.

Usually all of the scales on the males with the exception of those on the belly have one or two round or cone-shaped pearl organs on their distal portion. Some individuals have pearl organs on part or all of the ventral scales. The lateral line series of scales usually are armored with two pearl organs on each scale — one above and one below the pore. While the other scales usually have but one pearl organ, scattered individual scales have two and in a few instances three. The dorsal side of the head from the region of the occiput to the papillae of the snout is rather profusely covered with minute pearl organs. They frequently extend well down the sides on the cheeks and opercles, and may even occur on the branchiostegals.

Most of the scales dorsal to the lateral line in females have pearl organs although many of these are so small and weak that they are discernible only when magnified. As in the case of the males, these structures are more profuse on the head, although they become inconspicuous or absent near the snout. There is considerable individual variation among females with respect to the number and size of pearl organs on the scales adjacent to the caudal fin. Those on the ventral side of the caudal peduncle are sharply pointed similar to those of the males.

Conspicuous pearl organs occur on every ray of the caudal fin of males. The longest and strongest occur on the lower lobe, but these taper in size to the fork. Those in the upper lobe gradually decrease in size from the fork upward. The pearl organs near the base of the fin are larger than those at the posterior margin. There is considerable individual variation in the number and arrangement on the caudal fin of females. It can be stated, however, that only the lower half of the fin supports pearl organs and these are more numerous but smaller than those on the males.

Every ray on the anal fin of males supports pearl organs throughout its entire length. These occur in a single row on both

sides of the various branches as well as the basal portions and they are rather large and sharp. Regenerated anal fins usually possess a few pearl organs although these are likely to occur as elongated ridges rather than distinct sharply-pointed cone-like structures. The pearl organs on the anal fin of the females are limited principally to the three longest rays and mostly to the basal rather than the distal portions. Usually not over five or six occur per ray and they are typically smaller than those on males. It is not unusual, however, to encounter females with pearl organs on the anal fin as large as those on males.

The distal half of the ventral fin of males contain very small but (usually) sharp-pointed pearl organs. Most males have these on both surfaces, but they are larger and more numerous on the upper surface. The ventrals of the females are usually unarmored.

The pectoral fins of males support pearl organs. These are particularly noticeable on the ray branches of the upper surface. If present on the lower surface they are likely to be quite small and inconspicuous. They are absent on females.

Both sides of the dorsal fin of males usually are with pearl organs. Some males are practically devoid of these structures and in cases where only a few occur they are rather small. Females generally have no pearl organs on the dorsal fin.

The abundance and distribution of pearl organs on both sexes appear to be determined to a considerable extent by their general health. Vigorous highly pigmented individuals usually are better equipped with pearl organs than those that are more sombre-colored, and less vigorous. This is well exemplified by a six-inch male in the collection of preserved fish. Pearl organs are quite normal in number and size on the anal and caudal fin, but are small and poorly represented on other parts of the fish. Examination revealed that this specimen harbored two large ligulas (*Ligula intestinalis*) in his body cavity. The spermaries were sub-normal in size. Maximum development occurred on small or medium-size males.

Scales. Similarly as with common suckers, dwarf suckers exhibit considerable individual variation in the number of scales in the lateral line. It may be stated, however, that the average is somewhere between 65 and 70, probably about 68. As few as 64 and as many as 73 have been counted. The number of rows, on the other hand, remains rather constant, there being ten above and nine below the lateral line.

While the scales before the dorsal fin of dwarf suckers appear

to be smaller and consequently more numerous than those before the dorsal of common suckers, actually there are only thirty on most specimens. A good many individuals were examined and in no case were there as many as thirty-five and certainly not "over thirty-five" as have been reported by others (Greeley and Greene, '31; Hubbs and Lagler, '41).

Greeley and Greene ('31, p. 84) state that common suckers "from Adirondack waters of the drainage have smaller scales (the scales from nape to dorsal fin being in about 30 rows)". The common suckers collected at the Huntington Forest, likewise, contained 30 rows of scales before the insertion of the dorsal fin — the same number as the dwarf suckers. It must be concluded therefore that the two Adirondack forms cannot be distinguished subspecifically by means of this criterion. If common suckers in other regions have as few as 25 scales before the dorsal fin as they undoubtedly do, there would be added justification for a complete revision of the genus. The problem becomes more complicated by virtue of the fact that dwarf suckers have been reported by other authorities as having smaller scales in the region before the dorsal fin than those on the Huntington Forest.

The lateral line is extremely variable. In general it extends in a straight line, but the scales are sometimes so arranged that an offset, equivalent to the depth of one scale above or below the regular straight course, takes place. Interruptions are common, particularly in the posterior half, and the last five or six scales are likely to be without pores. These observations are in accord with those made by Kendall and Dence ('29) on Cranberry Lake dwarf suckers.

Fins. The height of the dorsal fin usually is slightly less than its length. This is particularly true of females and large males. In some of the small males, the height and length of the dorsal are about equal. Since Mather (1890) gives the height as equal to the length, he undoubtedly measured only small males.

The dorsal fin generally has eleven branched and one unbranched rays. Occasional specimens are found, however, with only ten branched rays. The anterior rudimentary (unbranched) rays were not counted because they were not clearly distinguishable. The last branched ray was divided to its base as in the case of common suckers. This fin is inserted at about middle of standard length.

The caudal fin is deeply forked with the upper lobe often slightly shorter than the lower lobe.

There are seven rays in the anal fin instead of five as reported

by Mather. The third ray is longest and, in the male, reaches the base of the caudal. Females, have a slightly shorter anal fin. In comparing anal fin lengths of similar size males and females it was found that there was actually a difference of four to six millimeters — sufficient to be obvious even on casual observation. While the anal fin of both sexes is equipped with pearl organs, those of the male are longer and stouter.

The ventral fins are slightly nearer the base of the caudal fin than to the anteriormost end of the snout. The point of insertion thus is directly below the mid-region of the dorsal base — about as stated by Mather. The third, or longest ray, in fish of comparable lengths is 4 to 5 millimeters longer in males than in females. Thus the ventral fins of a male 148 millimeters in standard length, for example, would be about as long as those of a female 185 millimeters in length. The difference in size may appear to be rather insignificant, but really is of sufficient magnitude to be recognizable on casual observation when the fish are close at hand. Reighard ('20, p. 7) mentions the greater length of the lower fin of male common suckers, but rightfully does not consider this differential characteristic so striking as certain others.

The pectoral fins have seventeen rays. The innermost rays are shorter than the others, and are not clearly discernible except under magnification. Mather's count of only fifteen rays may have been due to lack of magnification.

A number of dwarf suckers were encountered during the course of the field work that either had more than the usual complement of fins or had fins that were quite abnormal. One six-inch male had an extra fin on the right ventral side of his body about midway between the pectorals and the ventrals. While it was as long as a regular ventral fin it contained only two, but very stout, rays. Another five-inch male had an extra fin of seven rays attached to the caudal peduncle ventrally to the caudal fin. It was partly attached also to the lower lobe of the caudal at its base. It extended downwards and backwards similar to the anal. Strangely enough it was quite profusely covered with pearl organs. The caudal fin was normal in every respect except position—the extra fin had crowded it upwards. The anal fin was larger than normal so that the last few rays overlapped on the extra fin. There was a space of only 5 mm. on the caudal peduncle between the anal fin and the extra fin.

Both pectoral fins on a six-inch female were very short and stubby—scarcely one-half normal size. In fact they were only one-

half inch long and contained but three rays each. A four and one-half-inch male was minus the left ventral fin and from appearances had always been so. The right ventral was scarcely half normal length and contained only four rays. Another male, four and one-half inches long, had his pair of ventral fins emerging from a common point on the median ventral line. The fins were joined in a narrow plane along the middle ray giving the appearance of an "x" arrangement for the combination.

COMMON SUCKERS AND DWARF SUCKERS IN THE SAME HABITAT

Both gill nets and trammel nets were used in collecting fish in the lakes of the Huntington Forest, but the best results were obtained with the trammel net. If the collections obtained with the nets are indicative of the distribution, it would then appear that dwarf suckers and common suckers occupy quite different habitats within any particular body of water, at least during the summer months. Common suckers have a strong predilection for the littoral zone particularly where gross vegetation occurs in moderation. Their presence in this type of habitat possibly may be due to better foraging conditions rather than to other factors. If such is the case, periodic (possibly daily) migration from deep to shallow water or *vice versa* undoubtedly takes place. The fact remains that very few were captured in deep water.

Dwarf suckers often encroach upon the outer edge of the littoral zone, but normally they remain within the deeper areas except during the breeding season. Deep water possibly may be the principal prerequisite responsible for their distribution in the Adirondacks. The fact that they occur in all the lakes of the Huntington Forest, except Deer Lake, which is surprisingly shallow (maximum depth of 10 feet) gives added support to this theory. It also supports the contention that common suckers and dwarf suckers are sufficiently dissimilar to justify their differentiation subspecifically.

Considering its size, Wolf Lake has a proportionately greater population of dwarf suckers compared with common suckers than any other lake on the Forest. During the seven successive days in which the trammel net was operated in the lake early in August, 1941, a total of 106 dwarf suckers and six common suckers were captured. A small portion of the net in each of the sets was within the littoral zone. Several years previously (1934), sets placed completely within that zone yielded only common suckers.

At the conclusion of the netting activities in Wolf Lake, in 1941 the same nets were moved to Arbutus Lake, and operated in similar manner for five successive days, after which they were taken to Rich Lake for seven days. Only one set was made in the deepest part (26 feet) of Arbutus Lake, and it was the only one that yielded dwarf suckers. Common suckers were abundantly represented in each of the other sets. Similar results were obtained in Rich Lake.

During the course of the study five or six large female common suckers were taken on the spawning beds of dwarf suckers in the North Inlet of Wolf Lake. They were extremely shy and unruly—causing so much disturbance that it was necessary to remove them to prevent the dwarf suckers from becoming unduly excited. They were never observed mating with dwarf suckers. In a small inlet of Rich Lake where both forms were represented the dwarf suckers remained within a small section of riffles and did not associate with common suckers, which were further upstream in relatively deep and quiet pools. (See Figs. 23 and 24.)

SPAWNING MIGRATION

The dwarf suckers of Wolf Lake at the Huntington Forest always spawn during the latter part of May, sometimes extending the period a few days into June. During the first three years of the study (1938-1940 inc.), the first group entered the streams on or about May 25, but the following two years, (1941 and 1942), the season began about May 15. In 1943 spawning seemed to be at its peak when a census was made on June 1, indicating that the suckers probably had entered the streams four or five days previously. In each of the above-mentioned years, the fish appeared in considerable numbers from the very beginning and within two or three days had reached the peak of their population on the spawning grounds. The decline in population was less abrupt because a few individuals, mostly young fish possibly spawning for the first time, did not enter the stream until many of the early arrivals had finished spawning and had returned to the lake.

Another check was made on spawning dwarf suckers in May, 1944. A single fish was observed in the South Inlet of Wolf Lake on the evening of May 18, but it was evident that the prevailing sudden drop in atmospheric temperature would have a deterrent effect on the spawning activities. This proved to be the case for the population remained very low for the succeeding five days—fluctuating with the rise and drop of the temperature in the inlet irrespective of the time of day.

A census of dwarf suckers in this stream at 11 A. M. on May 24, after the atmospheric temperature became stable and more normal, accounted for 270 fish on the spawning beds. Judging from events of past seasons, the peak of the run would have occurred three or four days later.

There was a distinct correlation between the dates on which the ice left the lake and the dates marking the start of the spawning migration. In the 1941 and the 1942 seasons, the "break-up" occurred about two weeks earlier than it did in the other years, consequently migration began about that much earlier. The weather during both of these years was unusual for the Adirondacks region. In 1941 the last snowfall occurred on March 21, and there was no snow on the ground after April 12. The following winter was characterized by an extremely subnormal amount of snow (there never was more than two feet at any one time, and the ground was bare by April 14). Normally the lakes of the Huntington Forest are covered with ice in Mid-April, and there are several feet of snow, possibly subzero temperatures, with no indication of the spring break-up.

The following table (Table 4) shows spawning migration dates of dwarf suckers at Wolf Lake for seven years beginning with 1938, and the dates for each of these years on which the ice left the lake.

TABLE 4

Year	Date on which Ice left Lake	Spawning Migration Date
1938	May 1	May 25
1939	May 5	May 25
1940	May 4	May 25
1941	April 19	May 15
1942	April 20	May 15
1943	May 9	May 25 (?)
1944	May 4	May 18-19

As indicated in table 4, spawning migration occurs about three weeks after the ice leaves the lake. Slight variation in air temperature from year to year naturally accounts for at least a portion of the difference in time. The spawning dates of dwarf suckers for the other lakes at the Huntington Forest do not coincide exactly with those of the Wolf Lake suckers.

Dwarf suckers breed at a later date in certain other sections of the Adirondacks for Greeley ('34) found them spawning in the cold inlets of Lake Eaton "as late as June 19", while Greeley and Greene ('31) observed spawning on June 14 in a tributary of the Lower St. Regis Lake. The 1934 season at the Huntington Forest was somewhat later than was the case during any of the five years of the present study. Fish were still breeding on June 7 of that year, although the season was in its final stages.

Migration from Wolf Lake to the spawning streams was never observed, but the collecting data show that, normally, it takes place at night. On one occasion (April 21, 1941), there was definite proof that considerable numbers of suckers were entering and leaving the South Inlet of Wolf Lake throughout the daylight hours. This stream was seined very thoroughly in the morning and there was no question but that practically every fish (forty individuals) was collected and marked. By late afternoon most of those previously marked had left, and an entirely different group of about eight fish had taken their place. This was a rather unusual circumstance, however, which may be attributed partially, if not wholly, to disturbances and reactions brought about by high atmospheric temperatures, together with heavy precipitation. The maximum temperature recorded on that day was 86 degrees F, and 1.8 inches of water fell within a 24-hour period. The volume of water in this stream about doubled within a few hours, and the velocity likewise increased markedly. The water was sufficiently deep at the mouth of the stream to make ingress and egress of fish unnoticeable.

There were occasions when suckers were suspected running into the North Inlet of Wolf Lake in the daytime, and especially on rainy or cloudy days. But this stream was much larger and more diversified than the South Inlet, and consequently provided a better spawning habitat for the dwarf suckers, particularly during adverse weather periods. It would have been difficult and perhaps quite impossible to observe suckers migrating from the lake under such circumstances.

Raney and Webster ('42) observed that common suckers migrated mostly at night in Skaneateles inlet. The migration "started at dusk and continued with greatest intensity up until 10 or 11 P. M." They found that some of the common suckers went no farther upstream than a few hundred yards, but that some as far as four miles. The dwarf suckers of Wolf Lake inlets were limited to less than one-eighth mile, due to physical obstructions. In the North Inlet, frequently large numbers stopped for a few hours or even a full day in

a deep pool, concealed with brush, near the lake before proceeding to the spawning riffles.

It was not unusual to observe considerable numbers of fish in the act of migrating upstream throughout the daytime, although this phenomenon was more pronounced late in the afternoon. At least some, and possibly a considerable amount of this activity may not have been strictly normal because many of the fish involved had been captured on the spawning riffles earlier in the day, and later released several rods below these riffles. The few individuals that could be identified by abnormal markings were observed to re-migrate upstream to the spawning riffles until spent, regardless of the number of times they were transported downstream.

In the early part of the 1944 season observations made at night in the South Inlet, with the aid of a flashlight, revealed that at times most of the dwarf suckers were migrating to the lake, rather than from it. This was probably due to the sudden drop in atmospheric temperature and the corresponding drop in the temperature of the water in the stream, but with only a minor change in the lake itself. It appeared as if the urge to spawn was present, but could not be consummated because the habitat suddenly had ceased to fulfill the requirements. The suckers remained in the inlet when the weather became milder, and spawning was then much in evidence.

The principal spawning migration of dwarf suckers has never lasted more than two weeks at Wolf Lake, or at any other lake in the vicinity. In certain years all but a few stragglers left the spawning areas within ten days after the first arrivals entered the stream. In contrast to this, Raney and Webster ('42) found that the run of common suckers in Skaneateles Lake inlet extended over a seven weeks' period in 1939, although the main run occurred about two weeks after the first individuals appeared in the stream.

The dwarf suckers of Wolf Lake apparently never encounter any serious difficulty in making their annual spawning migration into the inlets. Throughout the period of this study the fish always found it possible to enter the inlets freely. Whether all the dwarf suckers of Wolf Lake utilized the stream for spawning is unknown. Possibly some of them found suitable spawning areas within the lake proper. If such was the case, then migration from deep to shallow water would be expected.

The inlets of Arbutus Lake, on the Huntington Forest, have never provided ideal spawning facilities for dwarf suckers. In fact the species was found in only one of its inlets (Fig. 22), and even that

stream generally failed to provide the desired qualities, and it was not utilized for spawning purposes during such times.

On May 8, 1942 a small-mesh trammel net placed parallel with the east shore, at a depth of 5 to 10 feet, yielded more than a hundred dwarf suckers during the night and early morning, and all had entered from the lakeward side, indicating that a shoreward migration was in progress, possibly for spawning purposes. This was not the normal summer habitat for dwarf suckers, and they were not taken there with this type of net at other seasons. The same set usually yields mostly common suckers and bullheads. The dwarf sucker population of Arbutus Lake is so great that only a small portion could possibly spawn in the inlet, consequently the others must spawn elsewhere. The situation in certain other lakes is quite comparable to that of Arbutus Lake.

Although common suckers are closely related to dwarf suckers, their spawning migration habits are somewhat different, at least in the waters of the Huntington Forest. The principal difference is the fact that common suckers migrate into the tributary streams to a very limited extent to spawn and there is little semblance of concentrated groups such as occurs with dwarf suckers. Small groups of spawning fish have been observed in the inlet of Arbutus Lake and in the pools at the base of the concrete dam spillway on Military Lake (Fig. 24). Likewise, an occasional large common sucker enters the North Inlet of Wolf Lake along with the dwarfs. Investigations indicate that common suckers are about as numerous as dwarfs in the various lakes. Certainly they must spawn somewhere, therefore it may be assumed that spawning is accomplished in the lakes.

Reighard ('15, p. 225) has observed that when common suckers spawn in the stream the principal requirements are swift water and gravel bottom. He believes that suitable bottom is more essential than running water, and that in lieu of suitable streams, the major portion of suckers may breed in the lakes. The lakes on the Huntington Forest are characterized by extremely soft, oozy bottoms everywhere, except on the shoals. It seems obvious, then, that both the dwarf and the common suckers migrate from deep water to the shoals if and when they spawn in lakes.

The speed at which dwarf suckers, or other fish species, migrate is difficult to determine, especially where most of the migration occurs from deep to shallow water, or from lakes to streams. Published information on this phase of the life history of the common sucker is practically non-existent and of course totally absent for dwarf suckers.

The following data on migration were obtained during the course of, and incidental to, the other studies on dwarf suckers. They are herewith presented as a basis for future contributions.

Upstream migration of dwarf suckers was comparatively slow, particularly where natural obstructions were sufficiently great to impede progress. The number, size and effectiveness of the obstructions as barriers had a direct bearing on the forward progress of the suckers. Normally, migrating fish rested a few minutes or even a few hours in quiet pools after negotiating an obstruction. Most of the obstructions in the Wolf Lake tributaries caused no serious handicap in reaching desirable spawning grounds. The suckers never were observed in the act of attempting to negotiate the dam at the upper limits of the spawning area in the North Inlet, which obviously was slightly too high to surmount. Possibly if desirable spawning areas had not been available elsewhere the suckers might have attempted to get beyond this obstruction. As a matter of fact the dam was obliterated during the freshets following the winter of 1943-1944 and the suckers subsequently extended their spawning grounds several yards farther upstream. Such is frequently the case in other streams inhabited with spawning dwarf suckers.

An example of an obstruction representative of the type that could be considered about the extreme upper limit of what can be surmounted was found in the inlet of Arbutus Lake on June 1, 1943. Dwarf suckers were observed in the act of climbing the falls produced by an abrupt rock-ledge with a sheer drop of about two and one-half feet and with a moderately fast current of water three to four inches in depth (Fig. 22). Several hundred suckers had assembled in the pool immediately below the dam. The writer watched the activities from a well concealed vantage point for about fifteen minutes, but failed to see any fish make the falls although numerous attempts were nearly successful. A very limited number of fish had been successful, however, and these were observed on the spawning beds above the falls.

Dwarf suckers like many other species of fish seem to have considerable endurance because they are capable of migrating long distances within the lakes proper when the occasion demands. This was demonstrated very well at Wolf Lake during the 1941 and 1942 seasons. Twenty-one male dwarf suckers migrated from the South Inlet to the North Inlet, or *vice versa,* a distance of slightly more than a mile, within the current spawning season. Some of the records compiled during the study clearly indicate that a few individuals travelled from

one end of the lake to the other within a single night. A number of other suckers made this same shift within two or three days. The time could not be determined more precisely except in the first instance because of the limitations of the marking system. It was reckoned from the earliest date on which they could possibly have been captured and marked that season. Thus in the 1942 season studies were not made in the South Inlet of Wolf Lake until late in the afternoon of May 21. The following morning a 4¾-inch male bearing a recently inflicted mark indicative of that stream was found in the North Inlet. Others were found in like manner on succeeding days, but after the first day there was no way of determining on what day they had been marked.

All but one of the twenty-one suckers guilty of changing their spawning stream within the current season had been marked originally in the South Inlet. This stream seemed to have lost its appeal as a spawning habitat during the last two years of the study due, perhaps, to the removal of certain cover by the C.C.C. or adverse weather conditions. That unsatisfactory conditions prevailed there is substantiated somewhat by the fact that during the last two years of the study the records reveal that many dwarf suckers failed to return to the spawning area after being released downstream, near the lakeshore, at the conclusion of the marking procedure. This reaction apparently cannot be considered a response to repeated annual disturbance by the writer since the dwarfs in the North Inlet were treated in similar manner without exhibiting this phenomenon. The North Inlet was by far the more desirable, as a spawning habitat than the South Inlet. There was one (possibly two) instance of this type of migration during the first three years of the study, but records were not made because it was the belief that an error had been committed in clipping the wrong fin. At the time the idea seemed preposterous that dwarf suckers could change their spawning habitat so quickly.

Raney and Webster ('42) have contributed the following record on the speed at which a common sucker migrated in Skaneateles Lake. "One downstream sucker marked at the weir at noon on May 19, 1939, was recaptured at 10 P. M. in a gill net set in the lake near the mouth of the inlet a distance of about one-half mile".

SPAWNING HABITAT

The spawning habitat of dwarf suckers consisted of very shallow riffles; oftentimes where the water was scarcely deep enough to cover their backs (Figs. 20 and 21). When this type of habitat was not

FIG. 21. Pools and riffles immediately above the big pool illustrated in figure 19. Used extensively by spawning dwarf suckers.

FIG. 22. Rock ledge in inlet of Arbutus Lake. Dwarf suckers ascend to the upper level only with much difficulty.

FIG. 23. Inlet of Rich Lake. Dwarf suckers spawn in the riffles near the man in the lower right. Common suckers, however, ascend to the deeper pools near the spillway.

FIG. 24. Pools at the base of the spillway used by spawning common suckers but not by dwarf suckers.

available they utilized riffles with deeper and faster water. The writer never has observed them in the act of spawning in the deep pools where the current was very slow, and they are not likely to use such places except, possibly, on rare occasions when more desirable habitats are not available.

Clean bottom of coarse sand or gravel are essential qualities of the spawning habitat. Many of the small permanent inlets of Adirondack lakes are of this general type, and consequently are potential spawning habitats. Temporary inlets do not meet the requirements and are avoided. Occasional small groups of breeding dwarf suckers will accept the lowermost clean small riffles of the stream which, frequently, are quite exposed. This may be due to crowded conditions elsewhere, or difficulties in surmounting obstructions. In any event, eggs deposited in such places are subject to greater losses from predators and shifting bottom materials, than those farther upstream. Most migrating suckers do not stop until some major obstruction prevents further progress. Generally dwarf suckers migrate less than one-fourth mile, frequently not over one-eighth mile, after entering the stream.

Cover, including both forest cover and that within the stream itself, is a very important, if not essential adjunct of spawning habitats. Dwarf suckers appear to avoid the unforested parts of the streams, but this may be pure coincidence, however, because the more desirable spawning sites generally are far enough inland to occur beyond the flood plain, typical of Adirondack lakes. The forest cover, undoubtedly, gives some security from winged enemies, but it reduces the intensity of light which, evidently, is more important. A reaction of this nature is to be expected from a species of fish that is unaccustomed to light most of the year.

Large boulders, overhanging banks, old logs, partially undermined trees or stumps, and various kinds of débris provide cover within the stream itself. Dwarf suckers frequently avail themselves of this cover and in so doing secure additional protection from light and enemies. The pools provide another type of cover, more important in many respects than those mentioned above. Dwarf suckers frequently congregated in great schools in the deeper pools when not actually engaged in spawning. That they have a greater feeling of security in the pools is exemplified by their behavior. They generally make a hasty retreat to the pools when disturbed, but their fears quickly subside after reaching their objective.

Another attractive feature of pools is, of course, the absence of

swift current, which makes it possible for the fish to rest with comparative ease. This is highly important because dwarf suckers utilize a great amount of energy from the time they enter the streams until they leave. The energy expended in reaching the riffles is considerable, but even more is utilized coincident with the spawning act. The fish take advantage of the pools to recuperate after negotiating a difficult obstruction during migration, or after an extended breeding session on the riffles. Then too the pools provide shelter for those individuals that are still unripe and consequently not ready to contact their mates on the spawning sites. They, likewise, accommodate excess males, of which there are many, as well as spent fish on the return journey to the lake. The serviceability of pools is greatly improved if logs, brush or other types of cover occur in connection therewith.

The preference for dark places and cover also was noted by Greeley and Greene ('31, p. 84) at the Lower St. Regis Lakes in the Adirondacks. They discovered that "the fish were spawning in a culvert which conveyed the creek under a road and the darkness inside this precluded detailed observation of the breeding behavior . . . it appeared that they avoided the sunny parts of the stream." Mather ('90, p. 164) states it "seeks shady woods" during the breeding season.

SPECIAL REACTIONS

Reaction to Inlet Waters. Dwarf suckers never have been known to spawn in any but inlet streams, even when seemingly desirable breeding habitats were available in outlet streams. This is characteristic of other sucker species as well as most freshwater fishes that habitually spawn in streams. The common shiners, *Notropis cornutus frontalis* (Agassiz), of Wolf Lake, however, react in an entirely different manner. They always spawn in the outlet and have never been known to select the inlet streams. The breeding season of the shiners begin a few days before, but overlaps that of the dwarf suckers.

Wolf Lake outlet was dammed by beaver several years ago, about a mile downstream. The resulting pond contains several species of fish, including dwarf suckers. The latter apparently migrated downstream as young, during highwater. A small group (perhaps two or three hundred) of these dwarf suckers breed in Wolf Creek outlet, which at this point changes its status to an *inlet* by virtue of an extensive beaver pond.

Reaction to Loss of Fins. Jordan ('05, p. 24) states that "the

paired fins are not in general used for progression in the water, but serve rather to enable the fish to keep its equilibrium." Most writers agree with Jordan in maintaining that the principal function of the paired fins is to maintain equilibrium, but very few make any assertions as to the *absolute necessity* of these appendages, in serving that purpose. Hegner in his revised text-book on College Zoology (Hegner, '26, p. 393) considers the paired fins so essential that the loss of two or more would markedly disturb the equilibrium of the victim. He claims that "if both pectoral fins are removed, the anterior end of the fish sinks downward; if a pectoral or both pectoral and ventral fins are removed from one side, the fish turns toward that side; and if all four lateral fins are cut off, the fish turns completely over with the ventral surface upward." Storer ('43, p. 576) infers that the loss of fins disturbs the equilibrium, but only temporarily when no more than two are removed. "Fishes deprived of one or two of the paired fins soon learn to compensate for the loss of them." Hegner very likely conducted experiments in the laboratory to determine the responses of fishes to losses of various numbers and combination of fins. Evidently his fish responded in a different manner than would normally occur in natural environments.

The dwarf suckers used in this study at no time exhibited any unusual behavior as regards their equilibrium. In fact those minus all five lower fins appeared to maintain their poise equally as well as individuals having the full complement of fins. Since only one fin was removed each year, except in cases where partial regeneration occurred, it is possible that the fish learned to compensate for the loss in each instance as mentioned by Storer (l.c.). Perhaps if more than one, or all, of the lower fins had been removed at the same time the effect would have been vastly different.

It is believed that the loss of even five fins did not create a serious handicap; otherwise the number of returns would not have been so great. Physically handicapped fishes, of course, are more vulnerable to capture by predators, than normal individuals; therefore it is believed that losses of marked fish would increase in direct proportion to the number of removed fins. Actually this was the case, but there was no means of determining whether or not the marked fish suffered proportionately higher losses than unmarked fish. Perhaps the losses of marked fish were entirely normal. The fact remains, however, that 36.3 percent of all the fish marked during the five-year study period managed to obtain all the necessities of life and, in addition, return on one or more occasions to participate in spawning activities. A con-

siderable number accomplished this feat for five successive years, and still appeared to be equally as healthy as unmarked individuals.

Breeding dwarf suckers did not appear to be disconcerted in the least over the recent loss of fins or the cumulative effect of past losses. Those that were liberated downstream beyond the main assembly of spawning fish after having been studied and marked soon obtained their bearings and within a few hours had rejoined their companions. The loss of fins from outward appearances neither discouraged the suckers from completing the spawning nor prevented them from surmounting the various obstructions and swift currents to reach their objective.

Male dwarf suckers demonstrated that their fins are non-essential in making contact with females during the sex act. In fact those with several missing fins accomplished the act without any noticeable lack of efficiency. Pearl organs formed on regenerated fins, but these were fewer in number and usually much larger than normal. Secondary sex characters on other parts of the fish were unaffected.

LIMNOLOGICAL RELATIONS

Temperature. Thermal stratification occurs in the lake and is fairly distinct during July and August. The thermocline occurs at a depth of 15 to 20 feet during most of July, but gradually descends until it reaches the 25- to 30-foot level in August. During these months there are ten to thirteen degrees difference in temperature between the surface and the bottom in the deeper areas of the lake. The minimum bottom temperature recorded during the summer of 1941 was 8.2° C at 11:00 A. M. on July 2 and the surface temperature at that time was 21.6° C.

The autumn overturn occurred during the second week in November in 1941 although the temperature had been quite uniform from surface to bottom for about a month previously. The lake, normally, is covered with ice from early December to early May—the spring overturn taking place about May 1.

Dissolved Gases. The amount of available oxygen in the deeper parts of Wolf Lake becomes very low except during the vernal and autumnal overturn periods. Coincident with the loss of oxygen there occurs a corresponding increase in the carbon dioxide content. The oxygen and carbon dioxide determinations at Stations 4 and 5, located in the two deep areas, are indicative of the entire lake. The determinations were made on July 24 and July 31 and are computed on the basis of cubic centimeters per liter of water.

TABLE 5. OXYGEN AND CARBON DIOXIDE DETERMINATIONS AT STATIONS 4 AND 5, WOLF LAKE, JULY 24, 1941

Depth (feet)	Free Oxygen		Free Carbon Dioxide		Fixed Carbon Dioxide	
	Station 4	Station 5	Station 4	Station 5	Station 4	Station 5
Surface	5.56	5.59	.63	.83	1.92	1.82
5	5.97	6.08	.63	.83	1.90	1.90
10	5.96	5.83	.51	.89	2.05	1.80
15	5.76	5.69	.71	1.14	2.05	1.80
20	4.20	5.66	1.32	1.16	2.02	1.80
25	4.65	4.46	2.93	2.73	1.87	1.90
30	5.83	2.34	4.05	7.31	2.00	2.38
35	2.43	0.19	6.83	10.49	2.17	3.44
40	1.25	0.00	7.96	11.25	2.45	4.35

Gill nets and trammel nets placed near these stations, for the most part, produced very poor or negative results, whereas those placed in somewhat shallower water yielded both dwarf suckers and brook trout in abundance. This also was demonstrated very well with sets made perpendicular with the shore and reaching into deep water—the bulk of the fish were captured between the littoral zone and the 25-foot contour. Since dwarf suckers are primarily bottom feeders the absence, or near absence, of oxygen and the corresponding increase in carbon dioxide at the lower levels would make such areas uninhabitable except for short periods at the turnovers.

Macroscopic Bottom Organisms. The macroscopic bottom fauna of Wolf Lake was comparable to that of other unpolluted Adirondack lakes—rather meagre. In the mucky areas tubificids and chironomids were the most abundant forms numerically. *Corethra* larvae and burrowing mayfly nymphs also were found in most of the double samples taken with a 6″ x 6″ Ekman dredge. Many empty tubes, mostly fragments, of tubificids and chironomids were found amidst the muck.

Compared with the deep areas the littoral zone was markedly more productive of bottom organisms, both quantitatively and quali-

tatively, but these could not be considered abundant. Numerous small caddis worms were found amidst sand while stonefly nymphs, mayfly nymphs, amphipods, crayfish, small bivalves, snails, fish fly larvae and other forms were taken in gravel and beneath boulders, sticks and brush.

Other Features. Wolf Lake was slightly acid and the acidity became more pronounced on the bottom of the deeper areas. The pH of the upper 15 to 20 feet of water had a pH of 6.4 at every station, but the acidity gradually increased below that depth until it reached a maximum of 5.7 at 40 feet.

Turbidity tests made in Wolf Lake throughout the summer months show that light penetrated to an average depth of sixteen feet. This corresponds with the maximum depth at which the littoral vegetation occurs. Likewise, the transition between sand or gravel bottom and the vast area of muck bottom occurs at approximately this depth.

Both phytoplankton and zooplankton were fairly common throughout the lake. *Cyclops* and *Diaptomus* were the principal copepods; *Daphnia, Leptodora, Bosmina* and *Holopedium* the principal cladocerans. *Nothalca* and *Anuraca* were the most common rotifers, but *Polyarthra, Rattulus* and *Triarthra* were well represented.

CORRELATION OF TEMPERATURE AND SPAWNING ACTIVITY

The spawning activities of dwarf suckers are influenced by changes in the temperature of water in the spawning habitat. If the changes are gradual, spawning is increased or decreased accordingly, and no decided disturbance or upset is evident. Sudden changes, however, cause pronounced upsets in the spawning activities. The correlations of atmospheric temperature, water temperature and the number of dwarf suckers captured on the spawning beds in the North Inlet of Wolf Lake during the 1941 spawning season are shown in graphical form in Figure 25.

Abnormal increases in atmospheric temperature at the approach of the spawning season usually cause a great influx of spawning suckers from the lake. These ripen very quickly, if they are not already ripe, and spawning is hastened to the extent that the season is of shorter duration than normal. Abnormal decreases in atmospheric temperature on the other hand may cause a decided curtailment in spawning activities and a cessation of migration from the lake. If the change is great, certain fish may not only cease spawning but return

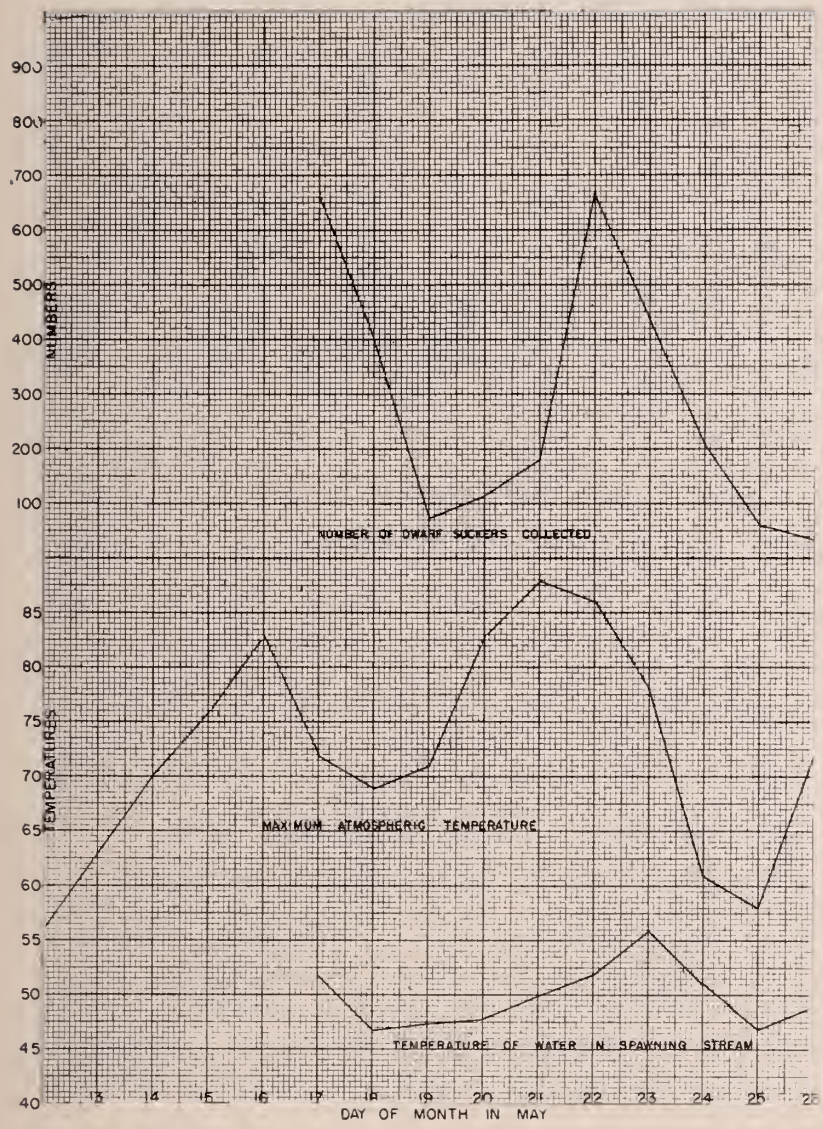

FIG. 25. Correlations of atmospheric temperature, water temperature and number of dwarf suckers captured on spawning beds in North Inlet during the 1941 spawning season.

to the lake until the temperature again becomes suitable. Temperature decreases in the stream during the spawning season usually are more sudden and therefore more devastating than temperature increases. This, of course, is to be expected at such high altitudes immediately following Winter, and particularly where the prevailing winds are from the northwest with frequent changes to the north. A passing cloud may precipitate an inch or more of cold water within a few hours. Such was the case early in the 1941 spawning season.

Dwarf suckers started their migration that season on May 15 during the midst of a rather warm spell when the temperature of water in the inlets had reached 51° F. which was about normal. The streams were well populated by May 17, and spawning was in progress. A severe storm swept in from the north in the forenoon of this day, and while it lasted only one and one-half hours, .86 inch of cold water had been deposited. This was accompanied with, and followed by, strong wind and lowered atmospheric temperature. As a matter of fact the atmospheric temperature dropped more than 20 degrees within 48 hours. Naturally the volume of water in the inlet was about doubled, but, more significantly, was reduced in temperature by five degrees.

Very few, if any, fish entered the stream on the night of May 17, and many of those already in the streams descended to the lake. The streams were practically deserted by May 19. The atmospheric temperature began to rise on May 20, and by May 22 had reached a maximum of 86 degrees F.—a gain of 25 degrees. The dwarf suckers responded accordingly and again reached the peak of their spawning activities such as prevailed five days previously.

On this occasion the water temperature increased very rapidly with the result that spawning was hastened considerably. Another sudden drop in atmospheric temperature accompanied by rain and hail occurred during the night of May 23 and the following day. This likewise caused the suckers to abandon the spawning streams. It so happened that many, if not most, of the fish were through spawning and this, perhaps, accounts for the fact that they failed to re-enter the streams again that season.

When the atmospheric temperature remains fairly constant throughout the breeding season the suckers reach the peak of their upstream migration within a few days and gradually diminish in numbers thereafter. Usually the period of decline in numbers is prolonged somewhat by virtue of the fact that young fish and especially females do not ripen as soon as the others.

Raney and Webster ('42, p. 140) observed that common suckers

migrating into the inlet of Skaneateles Lake showed a marked falling off in the numbers moving upstream when the water temperature decreased suddenly. While Stewart ('26, p. 150) mentions that the spawning season may be retarded by subnormal temperatures, he made no inferences with respect to sudden changes.

SEX RATIOS

The data on sex ratios were obtained from sexually mature fish collected on the spawning beds of two inlets of Wolf Lake during six successive years. Suckers collected at other seasons could not be sexed quickly or with absolute certainty from external characters, therefore the data on sex ratios for non-breeding fish are not included in this discussion. The data on sex ratios of breeding dwarf suckers captured in other waters of the Huntington Forest are likewise excluded, even though a considerable number of records are available, because collecting was accomplished at irregular intervals and was never extensive anywhere.

The sex of each sucker included in the discussion on sex ratios was determined positively. In most cases the sperm or ova flowed freely, while the fish were being measured and marked. If this did not occur voluntarily with ripe fish a sufficient amount of pressure was applied to the abdomen to force a showing of the sex elements. The enlarged abdomen of females, together with the various secondary sex characters generally were sufficient to distinguish unripe males from unripe females. Usually the sex of any fish could be determined solely from secondary sex characters, but the dissemination of sperm and ova conveniently served as a check on the determination. The large anal fin of male suckers studded with robust pearl organs was particularly helpful in distinguishing males from females.

Each year during the first few days of the spawning run the suckers were so plentiful that it was impossible to thoroughly seine and secure data daily for all the suckers in the spawning streams; therefore representative sample catches were made over the entire spawning area. This was particularly true during the early part of the study while various techniques were being devised for expediting the field work. After the data had been obtained on the advance group of suckers, usually it was possible to handle subsequent migrants within twenty-four hours after arrival. It can be assumed that, perhaps, a considerable number of suckers spawned and returned to the lake during the first few days of the season without being marked but that practically none of the late spawners escaped.

TABLE 6. SEX RATIOS OF DWARF SUCKERS FOUND ON THE SPAWNING BEDS OF THE TRIBUTARY STREAMS OF WOLF LAKE, HUNTINGTON FOREST

Year	Unmarked Fish				Unmarked and Marked Fish			
	No. of Males	No. of Females	Percent Males	Percent Females	No. of Males	No. of Females	Percent Males	Percent Females
1938.....	1,634	362	81.86	18.13	1,634	362	81.86	18.13
1939.....	1,199	778	60.64	39.35	1,799	825	68.55	31.44
1940.....	1,144	761	60.05	39.94	2,078	1,123	64.91	35.08
1941.....	2,726	493	84.68	15.13	3,596	662	84.45	15.54
1942.....	2,802	918	75.32	24 67	4,165	1,065	79.63	20.36
1943*.....	306	193	61.32	38.67	1,234	256	82.81	17.18
Totals....	9,811	3,505	.....	.....	14,506	4,293	.....	.....
Percent of totals...	.....	.....	73.68	26.32	.....	.....	77.16	22.83

* Entire population on spawning beds of North Inlet for one day only.

The most significant fact regarding sex ratios was that male dwarf suckers *always* greatly outnumbered the females on the spawning beds, not only from day to day, but throughout each spawning season. Unfortunately there are no available data on sex ratios of dwarf suckers other than those herewith presented so that comparisons cannot be made with specimens from other waters. In fact very little exact data on sex ratios have been published even for the common sucker, *Catostomus commersonnii commersonnii* (Lacépède). It would seem safe to assume, however, that the sex ratios of the common sucker are comparable to those of the dwarf sucker because their spawning habits are very similar.

Reighard ('20, p. 9) in describing the breeding habits of the common sucker in Michigan says that "During the breeding season males are at all times much more numerous on the rapids than females and during the greater part of the time none but males are present. It does not follow that males are actually more numerous than females. On the contrary data that I have collected at other localities and at times when the fish were not breeding indicate that the males and females are equally numerous. In the breeding season the females do not mingle with the males on the rapids until ready

to lay their eggs. But from time to time a female comes from her retreat in the deeper water above or below the rapid or from beneath the bank and takes her place on the rapid. If no males happen to be near she may lay quiet in one place for a considerable time." Spoor ('38) found the sexes of the common sucker about equal each year in Wisconsin.

The preponderance of male common suckers over females on the spawning rapids as stated by Reighard (l.c.) for Michigan corresponds with the data on sex ratios of dwarf suckers on the spawning streams at the Huntington Forest. There was no indication, however, of females living in seclusion above or below the rapids until ready to join the males on the rapids for the spawning act. The spawning streams used by the dwarf suckers possessed no inaccessible secluded places, and no fish of either sex was immune from capture. The only possible way the females could have escaped notice was by remaining in the lake until ready to spawn. This is highly improbable because actually many females entered the stream while they were in the unripe condition, particularly late in the breeding season when young females were more in evidence than those in the older age classes.

The number of marked and unmarked dwarf suckers of each sex collected annually and their percentage relationships are shown in Table 6. Several thousand spawning dwarf suckers collected at Wolf Lake over a period of six years, as indicated in this table, should be sufficient to formulate definite conclusions on sex ratios. Certainly they should indicate more than trends. While these fish are from a single body of water they are quite indicative of the situation in adjacent lakes on the Huntington Forest, as revealed from sporadic collecting and casual observation throughout the dwarf sucker spawning period for the past ten years. Likewise they coincide with observations throughout the summer months on dwarfs collected in Arbutus Lake in particular, but to a more limited extent in other lakes.

The data in the table show that male dwarf suckers were always in excess of the females. In certain years there were approximately two males for every female, but during other years there were as many as four or more males per female. Considering the number of different individuals (13,316) sexed during the 6-year period, however, the radio was about 2.8:1. The difference becomes greater (3.37:1) when the number from both sexes, represented by 18,799 fish, taken during the six years regardless of whether they had been

sexed and marked in previous years, are used in making the comparisons.

The sex ratios of recovered fish likewise varied considerably and there was some indication that a proportionately smaller number of females than males failed to return to the spawning grounds while the study was in progress. Possibly this may be considered mere coincidence rather than an indication that females are shorter lived or have a proportionately higher mortality rate, especially since the recoveries of suckers marked in 1939 represent a ratio of 2 : 1 in favor of males.

The following table (Table 7) shows the sex ratios of the 12,817 individual dwarf suckers, exclusive of all recoveries, marked during the five-year study period. Also the sex ratios of recoveries in subsequent years for each year group.

Table 7. Sex Ratios of Dwarf Suckers for Each of Five Successive Years at Time of Original Capture and Upon Return in Subsequent Years

Year	Number Sexed and Marked			Sex Ratio	Recoveries			Sex Ratio
	Total	Males	Females		Total	Males	Females	
1938.....	1,996	1,634	362	4.5 : 1	1,102	969	133	7.2 : 1
1939.....	1,977	1,199	778	1.5 : 1	952	644	308	2.0 : 1
1940.....	1,905	1,144	761	1.5 : 1	1,150	948	202	4.7 : 1
1941.....	3,219	2,726	493	5.5 : 1	1,097	1,000	97	10.0 : 1
1942.....	3,720	2,802	918	3.0 : 1	539	500*	39*	13.0 : 1
Totals...	12,817	9,505	3,312	2.8 : 1	4,840	4,061	779	5.2 : 1

* Number in North Inlet of Wolf Lake, June 1, 1943.

RETURNS FROM MARKED FISH

One of the most significant characteristics of dwarf suckers, as revealed from the data on marked individuals, was the habit in most cases of returning to the identical stream each year when actually there was a choice between two suitable spawning streams. This habit was demonstrated so well in the first two years of the study that during the other years when it was no longer possible to differentiate all representatives of the two inlets it was considered safe to assume that at least 95 percent of the marked dwarf suckers taken in each inlet had spawned in the same stream on previous occasions. This assumption unquestionably was very conservative.

Table 8. Summary of Returns Based on First Return During First Two Years After Marking

Year	Total Number Marked First Time	Total Number Returns First Time	Total Percent Returns First Time	Percent Returns First Year after Marking	Percent First Returns Second Year after Marking
1938....	1,996	830	41.08	32.41	5.76
1939....	1,977	949	48.00	44.86	1.87
1940....	1,905	626	32.86	30.86	1.83
1941....	3,219	1,146	35.60	33.48	2.11
1942....	3,720	539*	14.48	14.48	....

* From census of population in North Inlet on June 1.

Table 9. Summary of Returns of Marked Dwarf Suckers Showing First Return and Repeats

Year	Total Number Marked First Time	Total First Returns	Total Second Returns	Total Third Returns	Total Fourth Returns	Total Fifth Returns
1938....	1,996	830	315	111	24	2
1939....	1,977	949	290	61	8	....
1940....	1,905	626	211	63	....	....
1941....	3,219	1,146	247	....	....	....
1942....	3,720	539*	....	....	....	....

Of the 1996 dwarf suckers marked during the first season (1938), 647 or 32.4 percent were recovered a year later and all but eighteen of these recoveries had returned to the same stream. Thirteen of these eighteen had changed from the South Inlet to the North Inlet—from the smaller and least populated to the larger and more densely populated stream. No females were included among those making this change in spawning habitat.

TABLE 10. SUMMARY OF MARKED AND UNMARKED DWARF SUCKERS CAPTURED IN THE INLETS OF WOLF LAKE IN 1939

Marked in North Inlet in 1938			Marked in South Inlet in 1938		
Stream in which Recovered	Males	Females	Stream in which Recovered	Males	Females
North Inlet	467	59	South Inlet	100	3
South Inlet	13	0	North Inlet	5	0
Total Recoveries	480	59	Total Recoveries	105	3
Total unmarked	883	686	Total unmarked	331	77
Grand Total	1,363	745	Grand Total	436	80

TABLE 11. SUMMARY OF MARKED AND UNMARKED DWARF SUCKERS CAPTURED IN THE INLETS OF WOLF LAKE IN 1940

North Inlet *			South Inlet **		
Year(s) Marked	Males	Females	Year(s) Marked	Males	Females
1938	33	45	1938	34	3
1939	438	279	1939	127	7
1938, 1939	233	18	1938, 1939	36	0
Total Recoveries	704	342	Total Recoveries	197	10
Total unmarked	862	685	Total unmarked	274	85
Grand Total	1,566	1,027	Grand Total	471	95

* Not included are 37 suckers originally marked in South Inlet as follows: Two in 1938, 27 in 1939, four others in 1938 changed to this inlet in 1939 and four marked in 1938 and 1939 changed this year.

** Not included are five suckers originally marked in North Inlet as follows: three in 1938 and two in 1939. One male in the 1938 group returned in 1939 before changing and another changed in 1939.

In 1940 the returns, of course, included dwarf suckers marked in 1938 and 1939; either one or both, but with the greatest number in the latter season. Potentially there were 3,973 marked suckers in Wolf Lake but only 1,296 or 32.6 percent of that number were recovered during the season. There were forty-two individuals among the marked fish that had changed their spawning stream from that of some previous season. Twenty-seven of these that were captured in the North Inlet had been marked in the South Inlet during the preceding season and four others during the preceding two seasons. Four fish marked in the South Inlet in 1938 had used the North Inlet in both 1939 and 1940. Two others also marked in the South Inlet in 1938 were not taken in 1939 but appeared in 1940 in the other inlet.

Only five marked suckers were found in the South Inlet that had been taken previously in the North Inlet. Two of these had spawned in the North Inlet in 1938 and 1939. Another had used the North Inlet in 1938 but had come to the South Inlet in the next two seasons. The other two were marked for the first time in 1939. One female was found among those making the change in the spawning habitat. The number of dwarf suckers shifting from one stream to the other, as

TABLE 12. DETAILED RESULTS OF MARKED AND UNMARKED DWARF SUCKERS CAPTURED IN THE 1941 SEASON

North Inlet *			South Inlet **		
Year(s) Marked	Males	Females	Year(s) Marked	Males	Females
1938	2	1	1938	5	1
1939	20	13	1939	5	2
1940	436	97	1940	53	2
1938, 1939	0	1	1938, 1939	1	0
1938, 1939, 1940	74	1	1938, 1939, 1940	10	0
1938, 1940	7	2	1938, 1940	9	0
1939, 1940	9	0	1939, 1940	30	0
Total Recoveries	727	156	Total Recoveries	113	5
Unmarked Fish	2,442	456	Unmarked Fish	301	44
Grand Total	3,169	612	Grand Total	414	49

* 13 males and one female originally marked in South Inlet in 1939 not included
** One female originally marked in North Inlet in 1938 not included.

TABLE 13. DETAILED RESULTS OF MARKED AND UNMARKED DWARF SUCKERS CAPTURED IN THE 1942 SEASON

North Inlet			South Inlet		
Recoveries Year(s) Marked	Males	Females	Recoveries Year(s) Marked	Males	Females
1938	18	1	1938	18	1
1939	3	5	1939	1	0
1940	16	12	1940	10	1
1941	940	89	1941	46	4
1938, 1939, 1940	3	0	1938, 1939, 1940	1	0
1938, 1939, 1940, 1941	23	0	1938, 1939, 1940, 1941	1	0
1938, 1940	1	0	1938, 1940	2	0
1938, 1940, 1941	7	0	1938, 1940, 1941	1	0
1938, 1941	5	0	1938, 1941	1	0
1939, 1940	4	3	1939, 1940	1	0
1939, 1940, 1941	48	8	1939, 1940, 1941	7	0
1939, 1941	3	1	1939, 1941	1	1
1940, 1941	180	19	1940, 1941	12	0
Total Recoveries	1,251	138	Total Recoveries	102	7
Unmarked Fish	2,263	815	Unmarked Fish	549	105
Grand Total	3,514	953	Grand Total	651	112

recorded above, represents slightly more than three percent of the total recoveries of 1,296 for that year.

At the beginning of the 1941 season there were, potentially, 5,914 marked dwarf suckers in Wolf Lake, disregarding losses from all causes. During that year 1,001, or nearly 17 percent of these were recovered. In like manner at the beginning of the 1942 season there were, potentially, 8,157 marked dwarf suckers in Wolf Lake and during that year 1,498, or slightly over 18 percent of these were recovered.

The marking was discontinued after the 1942 season, but a census was made of the fish on the spawning beds on a single day for each of the four following years to determine the size of the population and

sex ratios as well as to obtain detailed data on returns of marked fish. In 1943 and 1944 it was found that approximately two-thirds of the suckers on the spawning beds were returns. To be more specific, in 1943, 991 or 66.5 percent of the 1,490 dwarf suckers taken on the spawning beds of North Inlet were recoveries with representatives that had been taken on each of the previous five years of the project. The 1944 census, which was made on a day prior to the peak of the spawning season, included 698 suckers from both inlets of which 352 or 50.4 percent were returns. Considering North Inlet alone, which had been given greatest consideration in previous years, 269 or 62.8 percent of the 428 spawning dwarf suckers were returns.

Table 14. Census of Marked and Unmarked Dwarf Suckers in the North Inlet of Wolf Lake, June 1, 1943

North Inlet			North Inlet		
Recoveries Year(s) Marked	Males	Females	Recoveries Year(s) Marked	Males	Females
1938	4	0	1939, 1940, 1941	3	1
1939	14	1	1939, 1940, 1941, 1942	8	0
1940	2	1	1939, 1940, 1942	1	0
1941	60	8	1939, 1941	4	1
1942	500	39	1939, 1941, 1942	2	0
1938, 1939, 1940	0	1	1940, 1941	12	1
1938, 1939, 1940, 1941	1	0	1940, 1941, 1942	62	1
1938, 1939, 1940, 1941, 1942	2	0	1940, 1942	6	1
1938, 1940, 1941, 1942	5	0	1941, 1942	240	7
1938, 1941, 1942	1	0	Total Recoveries	928	63
1938, 1942	1	1	Unmarked Fish	306	193
			Grand Total	1,234	256

On May 31, 1945 there were 991 dwarf suckers in North Inlet, consisting of 780 males (78.7 percent) and 211 females (21.3 percent). Three hundred and thirty-four (33.7 percent) of these were recoveries of marked fish. The population on this day was rather low

Table 15. Census of Marked and Unmarked Dwarf Suckers in the Spawning Streams of Wolf Lake, May 24, 1944

North Inlet			South Inlet		
Recoveries Year(s) Marked	Males	Females	Recoveries Year(s) Marked	Males	Females
1938	2	0	1938	1	1
1939	9	1	1939	7	1
1940	0	2	1940	1	0
1941	14	5	1941	2	3
1942	139	6	1942	48	3
1938, 1942	1	0	1938, 1939	4	0
1938, 1940, 1941, 1942	2	0	1938, 1939, 1940, 1942	1	0
1939, 1940, 1941	1	0	1939, 1941	1	0
1939, 1940, 1941, 1942	1	0	1940, 1941, 1942	1	0
1940, 1941	3	0	1941, 1942	9	0
1940, 1941, 1942	14	0			
1940, 1942	2	0			
1941, 1942	65	2			
Total Recoveries	253	16	Total Recoveries	75	8
Unmarked Fish	120	39	Unmarked Fish	145	8
Grand Total	373	55	Grand Total	220	50

and this was attributed to the sudden drop in temperature of the previous twenty-four hours.

The census in 1946 was taken on June 4 which, undoubtedly, was near the end of the breeding season. However, 100 fish were caught in South Inlet and 124 in North Inlet. Although only six of these suckers (all males) were recoveries they were represented by one fish marked in 1938, one marked in 1938 and 1939 and three marked in 1942. The two suckers in the lot that were marked during the first year of the study were at least twelve years of age, possibly older. They were less than six inches in standard length.

Tables 8 to 16 give a rather detailed summary of the returns of

marked fish. It will be noted that less than one-half of the marked dwarf suckers in Wolf Lake have been recovered and that the majority of those returning did so the year after the original mark had been inflicted. Although a sharp decline occurred on the second anniversary of marking, still a considerable number returned twice in succession and a very limited number appeared three or more years in succession.

Generally speaking, a proportionately greater number of marked females than males failed to appear in subsequent years. The 1940 season, however, was an exception in the case of North Inlet as may be noted in table 11. (342 of the 1,046 recoveries were females). The females that did return after being marked, with very few exceptions, used the same stream where originally taken.

One might speculate as to what has happened to those marked individuals unaccounted for in recoveries. A considerable portion of them undoubtedly should properly be credited to mortality from various causes. Some are overlooked and others may spawn in the lake.

TABLE 16. CENSUS OF MARKED AND UNMARKED DWARF SUCKERS IN THE NORTH INLET OF WOLF LAKE, MAY 31, 1945

North Inlet			North Inlet		
Recoveries Year(s) Marked	Males	Females	Recoveries Year(s) Marked	Males	Females
1938	1	0	1940, 1942	2	0
1938, 1942	2	0	1941	16	0
1939	6	0	1941, 1942	53	5
1939, 1940, 1941	0	1	1942	202	29
1939, 1940, 1942	1	0			
1940	3	2	Total Recoveries	296	38
1940, 1941	2	1	Unmarked Fish	484	173
1940, 1941, 1942	8	0	Unmarked Fish	780	211

FECUNDITY AND EARLY LIFE HISTORY

Egg Productivity. Dwarf sucker eggs are about the same size as those of common suckers. Eggs removed from formalin-preserved females average about thirteen per lineal inch or a diameter equivalent of .0769 inch (slightly less than 2 mm.) per egg. According to vonBayer's table, this is the equivalent of about 150,000 eggs per liquid quart. The number of eggs per female normally varies directly with the individual and particularly with its length. Thus it was found that a 4¾-inch female produced, on the average, only 775 eggs, while a 5-inch female had slightly less than 1,000 eggs, a 6-inch female about 1,300 and a 7-inch female 1,500 eggs. In selecting fish for the egg counts the writer endeavored to take only those that showed no evidence of having partially spawned. Some of the fish, however, may have deposited a few eggs prior to capture in which event the condition of the ovaries would not be noticeably affected.

Stewart ('26) did not count the eggs of common suckers within the size range of the dwarf sucker. The smallest females from which he obtained data on egg-productivity included a 12-inch individual with 18,000 eggs and a 15-inch individual with 31,200 eggs.

Referring to Table 3 it will be observed that the entire catch of female dwarf suckers averaged slightly less than six inches and accordingly produced an average of about 1,300 eggs per fish. This means that in 1940 and in 1942, when the maximum number of females were found in the spawning inlet streams, the annual output of eggs was nearly one and one-half million, but in the other years considerably less. In all probability the output was somewhat greater because it must be admitted that some of the females evaded capture, particularly during the first season, while techniques were being developed for handling large numbers.

Incubation. On May 24, 1942, which date was near the end of the spawning season, about a quart of dwarf sucker eggs were stripped and fertilized at the North Inlet of Wolf Lake. After they had become thoroughly hardened they were transported to Oneida, N. Y., a distance of more than one hundred miles, and placed in jars at a private hatchery where the water supply registered 60° F. The temperature increased quite rapidly thereafter, so that on May 28 and 29 it registered 70° F. A cold rain reduced the temperature to 66° F. on May 30, and to 62° F. on June 1. The eggs hatched on the last-mentioned date, eight days hatching time. The fry were actively swimming on June 4 with the water temperature at 64° F. They were

planted three days later in a private pond in water registering 74° F. at planting site. The quart of eggs produced about 1,500 fry—the heavy losses being attributed mainly to low fertility resulting from inadequate facilities at the collecting site.

These incubation records for dwarf sucker eggs agree very well with those of Raney and Webster ('42) for common suckers in Skaneateles Lake inlet. The incubation period was about a week in each instance.

Development of Fry. It has been impossible thus far to differentiate with certainty dwarf sucker fry from common sucker fry. The former, apparently, abandon the spawning beds immediately after hatching and thereafter spend the greater part of their existence in deep water. Schools of sucker fry occasionally were observed in shallow water and these may have been the young of either or both subspecies, because so far as is known the young are quite similar in appearance, and the characteristics used in distinguishing the adults are not apparent at that stage of development.

Collections obtained at various times and circumstances in the lakes of the Huntington Forest indicate that two distinct size classes are represented, and this may be significant. These classes, however, are not too clearly differentiated until a year's growth has been attained. Four small suckers collected in shallow water at the south end of Wolf Lake on June 3, 1933 obviously were yearlings as they were only one and one-half inches in total length, and the date almost identical with the spawning season. Additional collections from this lake on July 14 indicated that considerable growth had taken place—the lengths then ranged from 2¼ to 3¾ inches, total length. These sizes compare favorably with young from artificially fertilized eggs that were reared one year in a hatchery pond followed by one year in an aquarium.

In Catlin Lake and its tributaries, sucker fry obtained in shallow water during July and August revealed that growth was much faster than was the case in Wolf Lake. Fry of the current season taken on July 25 were quite uniformly ¾-1 inch in total length. Another collection of 35 fry, taken on August 14 of the same year, ranged from ⅞ to 1¾ inches, with 1½ inches as the average. Yearling suckers taken in the inlet of Deer Lake ranged from 3¾ inches to 4 inches. It seems quite obvious that the sucker fry taken in Wolf Lake were dwarfs, and that the others were mostly, if not entirely, common suckers. While the comparisons are not made with fry from the same lake the habitats, nevertheless, were quite similar in many respects.

Carbine ('43) reports that common sucker fry artificially hatched and reared in ponds attain an average length of 3-4 inches at the end of 186 days (November 17). Hubbs and Creaser ('24), however, state that those from Douglas Lake, Michigan, average only 72 mm. (2⅞ inches) the first year. The Douglas Lake records compare very well with those of Oneida Lake (Adams and Hankinson, '28).

FOOD AND FOOD RELATIONS

Dwarf suckers like many other species of fish with inferior type of mouth feed on bottom organisms. The bottom of Wolf Lake, in the areas customarily inhabited by the suckers the greater part of the year, consists of muck—very soft and oozy in texture and sufficiently deep to completely cover all mineral soil. This type of bottom is never particularly rich in macroscopic animal organisms, and Wolf Lake is no exception. Blood worms (*Chironomus plumosus*), phantom midge larvae (*Chaoborus punctipennis*) and tubificids are the most frequent representatives of the bottom samples. Small clams (*Sphaerium* sp.), mayfly nymphs, caddisflies, snails and small scuds* occur in very limited numbers.

The stomach and intestinal contents of several dwarf suckers collected in the lake during August have been analyzed, and it was found that practically all the animal organisms discovered in the bottom samples were represented. The suckers customarily had utilized a preponderance of one organism to the near exclusion of others. Thus one sucker had devoured 23 clams (*Sphaerium* sp.) and four *Chironomus*. Others had fed almost exclusively on *Chironomus*. Mayfly nymphs were the principal items in several others, and caddisflies were well represented in several. Usually considerable muck and other extraneous materials were found amid the strictly food items. Some of this material evidently represented tubes or cases used by the bottom fauna.

Two dwarf sucker fry about two inches in length that were transferred from a rearing pond to an inside aquarium removed the greenish layer of scum which had accumulated on the sand and fine gravel bottom over a period of several months in a surprisingly short time. The bottom of this aquarium was always free of organic matter thereafter. However, there was little evidence that feeding had taken place on the glass sides of the aquarium.

Suckers, in general, feed on eggs of other fish whenever they are available and occasionally they may even devour their own eggs.

* *Hyalella azteca* (Saussure) identified by Leslie Hubricht.

The digestive tract of those collected on the spawning beds was practically devoid of food and there was no evidence of fish eggs. Kendall and Dence ('29) observed dwarf suckers foraging in association with other species of fish on the spawning beds of red-sided suckers, *Catostomus catostomus nanomyzon* Mather, and brook trout at Cranberry Lake, but none of the limited numbers of dwarf suckers captured under such circumstances contained fish eggs. Small brook trout, on the other hand, taken at the same time, had considerable quantities of sucker eggs in their stomachs, indicating that eggs were available. Common suckers feed on practically the same organisms as do the dwarf suckers in the lakes of the Huntington Forest. The bulk of the food is aquatic insects with molluscs forming a considerable portion.

Dwarf suckers are useful principally in the capacity of a forage species for game fish. The extent to which they are utilized in that respect is, of course, unknown, but it is believed to be considerable. In considering the food and feeding habits of dwarf suckers the question arises as to whether their value as a foraging fish is sufficiently great to compensate for the food they utilize and which otherwise might be available to game species. Competition for the limited supply of food naturally must be very keen. The inferior type of mouth of the sucker should be a great advantage in securing bottom organisms. Fishes with terminal mouths on the other hand might have the advantage with respect to the fauna above the bottom. Bottom dwelling forms that escape the suckers and other enemies are potential food for fish, when they emerge coincident with the act of metamorphosis.

AGE DETERMINATIONS

An attempt has been made to determine the ages of dwarf suckers by studying the growth rings on scales. Some of the scales for these determinations were obtained from live spawning fish, others from preserved fish obtained each year during the course of the study. The annuli of dwarf sucker scales are much more difficult to identify than those of the common sucker. While the scales are relatively small this causes no particular inconvenience—it simply necessitates proper magnification. Magnification, however, failed to reveal any marked crowding of the circuli; consequently it was necessary to place greatest reliance on the irregularities in the structure and the course of the circuli. In some instances the annuli were so poorly defined that their number could not be ascertained positively

Beckman ('43) made a thorough investigation of the literature pertinent to the annulus formation on scales of fish, and published the results of his findings on the annulus formation on scales of certain game species, all with ctenoid type. In summarizing his data the author considers temperature to be the "primary factor in annulus formation" with food rated as of secondary importance. Spawning had very little, if any, effect on the time of annulus formation. His review of the literature reveals that in making age determination of fish by the scale method too much reliance has been placed on assumption rather than on exact knowledge. This accounts for the diversified and, oftentimes, conflicting opinions on the subject. Beckman (l.c., 285) intimates his uncertainty with respect to the scale method by the statement that "the general validity of this method has been assumed." Furthermore he adds that "The assumption that the annulus is a year mark and that but one annulus forms each year has been and still is under criticism." The statement (l.c., p. 285) that "the annuli on the scales do provide a clue to the fish's age and growth has been demonstrated for many species and is now confirmed for the material used in the present study" is, in the writer's opinion, particularly applicable to dwarf suckers and unquestionably to many other species, as well.

Blair ('38) found that the ages of landlocked salmon, from waters of New Brunswick, in about 67 percent of the cases could not be determined correctly from the scales. He says (p. 520) that the fish were "Anywhere from one to four years older than is recorded on the scales. This is due to the fact that the mature fish, spawning consecutively for a number of years, grow very little from one year to the next, consequently the scales show little, if any, growth, and this coupled with extensive scale absorption, renders the scales difficult, or impossible to be interpreted correctly."

There are records for a few dwarf suckers that have been on the spawning beds annually for as many as six consecutive years. Two of these have been preserved as museum specimens for future study and reference. Both were males, 5¾ and 6¼ inches, respectively, in standard length. Two additional specimens, each 6¾ inches long, that had spawned on five consecutive seasons were also preserved. While it is not known how old these fish were at the time of the initial marking or how many times they had spawned previously, it is certain that the first-mentioned group were, at least, eight or possibly nine, years of age—probably older. Careful study of scales from these specimens under varying degrees of magnifica-

tion and light intensity revealed that the number of so-called annuli were not indicative of their true age. On the contrary the annuli appeared to be more indicative of the number of years subsequent to sexual maturity.

The scales of a 5¾-inch male taken on June 1, 1943 showed only six annuli. Previously it had been captured on five consecutive years and thus was on its sixth known spawning trip to the North Inlet of Wolf Lake. Assuming that it may have been on its first spawning migration when originally captured in 1938, this fish should have been at least nine years of age. Another male, 6¼ inches long, also on its sixth consecutive spawning trip, taken on the same date, had eight annuli.

Two male dwarf suckers 5¾ and 6 inches in standard length captured on May 24, 1944 had been marked originally in 1938, but had been recovered and subjected to additional marks three other seasons. While each of these fish had spawned at least seven times their scales had only seven annuli.

Data on preserved specimens that are known to have spawned more than once include two 6½-inch males with seven annuli each, two 6¾-inch males and another 6¼ inches, all with six annuli that had spawned at least five times; four males 5½, 5¾, 6 and 7 inches in length with six annuli each that had spawned at least four times; three males 5¾, 5¾ and 6¾ inches in length with 6, 5 and 6 annuli respectively, had spawned at least three times; three males 6, 6 and 6½ inches in length with five annuli each had spawned at least five times; six males 5, 5, 5¼, 5½, and 6 inches in length with five annuli each, one male 5½ inches in length with four annuli, one male 5¾ inches in length with six annuli, and one female 5½ inches in length with five annuli had spawned at least twice. It has been assumed in certain instances of the above discussion that the dwarf suckers spawned annually after reaching sexual maturity as they undoubtedly do. The fact that certain individuals were not recorded each year after the initial marking may indicate that they escaped capture.

At the conclusion of the field studies on spawning dwarf suckers in May, 1941, scales for age determination were obtained from fifty-three fish including some individuals that had been marked two and three years previously—just completing their third and fourth known spawning season. Those captured on four successive years consisted of two males, 4¾ and 5¾ inches in length, that had only four annuli each; three males 5, 5¼ and 6 inches in length that had five annuli each; and one 6-inch male with six annuli. Ten fish in this group

that had experienced three known spawning periods had annuli as follows: one five-inch male, four; males 5, 5, 5½, 5½, 5¾ and 6 inches in length five each; males 5¼, 5¾ and 6 inches in length, six each. The other suckers in this series, marked for the first or second time, possessed a varying number of annuli (three to six).

In comparing the number of annuli with the standard lengths of about two hundred individuals of assorted sizes, chosen at random, it was found that there was a definite and consistent correlation in the smaller-size groups, i.e., the four-inch and four and one-quarter-inch classes. Beginning with the four and one-half-inch size, each succeeding size class became more varied with respect to the number of annuli. This, however, was expected because the majority of the fish used in the age determinations were males which generally range between five and six inches in standard length—average slightly less than five and one-half inches. In other words most male dwarf suckers acquire about two additional inches after reaching sexual maturity. The amount and rate of increment after becoming adults naturally varies with the quality and quantity of food, general health, number and species of parasites and other factors. Some individuals evidently cease growing at an early age, while others may perhaps by virtue of a better environment, continue to put on increment even beyond that of the average-size for the species.

Dwarf suckers as small as 3½ to 4 inches in standard length occurred in considerable numbers on the spawning areas. Unfortunately scales for only four of this size were available for age determination. Each of these had three annuli. An occasional sucker in the other size groups, likewise, possessed only three annuli and these became progressively scarcer with each increase in size group.

Most of the 4¼-inch suckers as well as the 4½-, 4¾- and 5-inch individuals had four annuli. Furthermore about one-third of the suckers in the 5½-inch group, one-half of the 5¾- and 6-inch groups had five annuli. None of the fish had more than seven annuli—few as many as seven. The smallest fish possessing seven annuli was 5½ inches long. There were more representatives, however, in the larger size groups.

The maximum age attained by dwarf suckers cannot be positively determined on the basis of the maximum number of annuli because, as mentioned elsewhere in the report, these structures are not formed each year—possibly not at all or infrequently in the juvenile stage. It would seem reasonably safe to assume that the normal maximum span of life is at least twelve years. Two male

suckers marked in 1938 on the spawning beds were recovered eight years later—also on spawning beds. These were at least twelve years of age.

Although considerable work has been done on age determination of common suckers, Spoor ('38) apparently is the only author that has presented data relative to the life span for that species. He includes data for "age-groups" as far as eleven years. The frequencies for fish in that age-group were very low, as were those for age-group ten. Stewart ('26), Spoor ('38), and Raney and Webster ('42) have made intensive studies on age determinations of common suckers, considering the number of annuli on the scales comparable to the true ages. Evidently none of these authors had adults of known age for comparison to check on their determinations. This is generally considered not only useful but highly essential before judging correct ages. The writer was fortunate in having at his disposal a considerable number of sets of dwarf sucker scales from spawning fish that had been marked annually from one to five times. The fish from which these scales were taken therefore were known to have been sexually mature for, at least, as many years comparable to the number of times captured and marked. This, admittedly, is only a step in advance of what has taken place previously, but invaluable, at least as concerns dwarf suckers, in proving that the number of annuli does not represent the true age.

It is quite evident that oftentimes age determinations are made by interpolation or by guessing rather than by positive methods because the circuli may give no clue to the presence of certain annuli. This weakness is universally recognized. Thus Raney and Webster ('42, pp. 145-146) mention that "No experimental work was carried out to check the validity of the criterion used in determining the age. Consequently the ages assigned to the various specimens are reliable only if it is assumed that standards involved in judging the age of better known species are equally applicable here." "The position of the first annulus was usually difficult to determine. It was located relatively close to the focus of the scale and was usually poorly defined. Scales of yearling specimens from the lake showed similar indefinite characteristics in the first annulus. Occasionally the occurrence of several marks near the scale margin which could not always be interpreted as annuli made an age assignment unreliable or impossible."

Spoor ('38) likewise expressed some doubt regarding the validity of his age determination of common suckers. He says (p. 463)

that "The annulus of the common sucker, then, appears to be marked by a crowding of the circuli and cutting over of these crowded circuli at or near the point where they enter the posterior quadrant of the scale."

The lack of crowding of circuli at the annuli on the scales of Wolf Lake dwarf suckers may be attributed to the prevailing low temperatures throughout the year and the general feeding habits. It is definitely known that dwarf suckers are partial to deep cold water and that they do not cease feeding during the Winter. The more or less evenly cold temperature that prevails from season to season evidently has a regulative effect.

Stewart ('26, p. 172) observed that common suckers "Seined in November from a large spring showed virtually no seasonal variations of the sort described as usually present [Variations in spacing of circuli.] Though sexually mature (6 to 10 inches) not even the markings were noticeable. This fact, taken alone, would point to the direct regulative effect of an evenly cold temperature. Again the greatest contrasts in spacing have been observed in fish from pools between falls, where they probably have remained all their lives subject to extremes of warm and cold water."

ECONOMIC AND SOCIAL RELATIONS

In addition to dwarf suckers, eleven other species of fish are known to occur in Wolf Lake—all of which are strictly native to the Adirondacks. Only two of these are game species—brook trout, *Salvelinus fontinalis fontinalis* (Mitchill), and lake trout, *Cristivomer namaycush namaycush* (Walbaum). Netting operations indicated that brook trout were fairly abundant, but the lake trout quite uncommon. Most of the larger brook trout (those above the 8-inch class) were very slim so that their weights were rather light compared with their lengths. The largest specimen captured in the nets, for example, was 17 inches in total length, but weighed less than two pounds. The lake trout, on the other hand, that have been observed in Wolf Lake are very large and in extremely good flesh. The largest individual observed measured 35 inches total length and weighed twenty pounds. It's scales showed eight annuli.

Brook trout appear to be suffering from the effects of overpopulation; the result of natural undisturbed processes over a long period. The lake has not been stocked in many years, if ever, and it has been closed to fishermen in recent years. While the supply of forage fishes is entirely adequate to support a much greater popula-

tion of brook trout the invertebrate life in the lake is not sufficiently substantial to provide a diversified diet of the type necessary for maximum growth and development.

Small dwarf suckers undoubtedly provide food for both species of trout and they should be more valuable for this purpose than most of the other species of forage fishes because the trout and dwarf suckers have a common habitat. It is definitely known that only a small portion of the dwarf sucker fry reach maturity, and since brook trout and lake trout normally include many small fish in their diet it seems logical to conclude that these predatory fishes are, at least, partly responsible in maintaining normal dwarf sucker populations.

The other species of fish inhabiting the lake have no particular economic importance. The red-bellied sunfish, *Lepomis auritus* (Linnaeus), while fairly abundant is too small to be an attractive panfish. The common bullhead, *Ameiurus nebulosus nebulosus* (Le Sueur), is so rare (only one specimen has ever been recorded for the lake) that its importance is inconsequential. Common suckers are well represented and are a potential, though not commonly used food resource. Numerically the most abundant fish in the lake appears to be the common shiner, *Notropis cornutus frontalis* (Agassiz). Great schools of this species frequently inhabit shallow water throughout the Summer and are conspicuous because many of them are heavily infested with *Ligula intestinalis*. Red-bellied dace, *Chrosomus cos* Cope; horned dace, *Semotilus atromaculatus atromaculatus* (Mitchill); and cut-lips, *Exoglossum maxillingua* (Le Sueur), are very common. Black-nosed dace, *Rhinichthys atratulus atratulus* (Hermann), and northern sculpin, *Cottus cognatus* (Richardson), occur in limited numbers in the lake immediately adjacent to the inlet streams. The sculpins encroach on the dwarf sucker spawning grounds and take a few eggs.

The population of fish species inhabiting shallow water of the lake proper, regularly or periodically, is controlled to a considerable extent by predatory birds and mammals. These animals, however, may not affect the dwarf sucker population very seriously, either because of their limited numbers or by virtue of their particular feeding habits.

The most likely avian predator would be the common loon because it frequents all parts of the lake, and is an extremely fast swimmer below the surface. At least one family of loons (two adults and one or two young of the season) habitually frequent Wolf Lake each Summer. Sometimes these family groups are host to visitors

from nearby waters as was the case on August 8, 1941 when seven adults were observed in a group and engaged in various antics such as swimming with outstretched wings, loud calling, sudden dashes or diving, performed mostly in unison.

American mergansers and great blue herons frequent the shallow areas and undoubtedly capture many fish during a season, but so far as is known common shiners, sunfish and horned dace are the principal victims. It is conceivable that young dwarf suckers might on occasion wander into shallow water along with young common suckers and thus become prey for the above-mentioned predators. The young of the two subspecies of suckers, however, never have been positively differentiated, consequently if young suckers were taken it would be difficult to determine if dwarfs were included.

A few pair of herring gulls nest on the large boulders in Wolf Lake each year; the greatest number for a single season being five pair. As in the case of loons, individuals from neighboring areas occasionally visited the Wolf Lake group. Dwarf suckers apparently are not an important item in their diet since the abundant excreta deposited on the nesting boulders contained mostly ctenoid rather than the cycloid type of scales possessed by dwarf suckers.

As many as five otters have been observed in the family group at Wolf Lake. The group usually foraged along the east shore; sometimes getting out into the dwarf sucker inhabited areas. The excreta found near their favorite slide during the summer of 1940, however, consisted mostly of crayfish fragments.

From the above discussion it would seem that the avian and mammalian enemies of dwarf suckers on Wolf Lake proper are rather insignificant. Brook trout, lake trout and common loon are potential enemies because they are known to frequent the dwarf sucker habitats. A considerable mortality occurs, as may be expected, while the fish are in in the streams during the spawning season. Concentrations of fish, or any other forage animal, are always inviting to predators, particularly when circumstances, such as exhibited by the suckers, make it possible to obtain abundant food with the minimum amount of effort.

Predators never were observed in the act of catching suckers, although special trips were made to the streams at night for that purpose. Attempts to catch them in steel traps likewise failed. It would seem that only one predatory species was guilty of the offense because the unutilized killed fish bore the same type of tooth- and claw-marks, and further indicated that the predator had a decided

preference for the head portion—the balance of the fish frequently remaining undamaged. Some of the dead fish were untouched save for deep flesh wounds. Perhaps some of these gashed fish had escaped the attack, but died as a result of the wound. This is borne out by the fact that an occasional live sucker was found in the streams with such wounds.

The mammalian predators that are known to occur in the general vicinity are: racccoons, red foxes, black bears, fishers, otters and mink. American mergansers, common loons, herring gulls and great blue herons occur in the lake and have been observed near or at the mouth of each stream. It is conceivable that many fish are completely devoured, in which case there would be no means of even hazarding a reasonable guess as to the probable losses. The greatest losses occur early in the season before the field work gets underway. The writer suspects that otter ascend the inlets during the night and are responsible for most of the losses. Foot prints observed in coarse sand along shore, while rather indistinct, certainly look much like those made by otter. There is, also, the possibility that certain other predators may leave no evidence of their activities—they may carry their prey to some remote area before proceeding with the meal or making a cache.

A rather unusual condition was found with respect to a live and very active dwarf sucker 138 mm., in standard length, collected in the North Inlet of Wolf Lake on June 27, 1944. Part of the skull, involving an area 9 mm. by 9 mm. and inward to the brain, recently had been removed from that part located between the nostrils and the eyes. Examination in the laboratory under magnification revealed that both olfactory nerves and one olfactory bulb had been taken as well as about one-half each of the other olfactory bulb and the cerebral hemispheres. The concise manner in which the various parts were severed indicates that this injury undoubtedly was caused by some predatory bird, possibly a herring gull, since about a dozen adults of that species were nesting in Wolf Lake at that time. While the victim showed no visible effects from the injury when captured, undoubtedly it would have died in a few days. This was the only dwarf sucker in the spawning stream on this date and furthermore the only occasion when dwarf suckers occupied the area after the regular spawning season.

Dwarf sucker eggs were surprisingly well concealed in the sand and gravel of the spawning beds so that scarcely any were exposed and thus subject to loss by spawn-eating fishes. At least a part of

the uncovered eggs are consumed by the associated northern sculpin, *Cottus cognatus* Richardson, and brook trout, *Salvelinus fontinalis fontinalis* (Mitchill). Neither species lived strictly on sucker eggs, but varied their diet with insects, including *Simulium* pupae and adults. One four-inch brook trout taken in South Inlet May 24, 1944 had fed almost exclusively on sucker eggs, and to the extent that its belly was greatly distended.

The trout breed in the dwarf sucker streams during the autumn, the eggs hatch in late winter or early spring, and the young reach the stage at which they begin to take natural food when sucker eggs become available. The fry increase in abundance as the season progresses, and undoubtedly there are many more than are actually observed because their markings, coupled with the fact that they adhere very closely to the bottom, make them rather obscure.

One sculpin collected on the spawning beds of the South Inlet contained thirty-six sucker eggs in addition to a mayfly nymph. Others had taken a few but the bulk of their stomach contents consisted of a variety of insect larvae and adults. More than a hundred eggs were taken from a four-inch brook trout. Yellow perch do not occur in Wolf Lake and seldom enter the dwarf sucker spawning beds of other streams. A school of about 50 individuals averaging two to three inches in length, however, were observed on one occasion in the spawning stream of Arbutus Lake. The lone individual that was captured from the group had been eating sucker eggs. It is to be presumed that the others were guilty of the same offense.

Horned dace, *Semotilus atromaculatus atromaculatus* (Mitchill), also spawn in the inlet streams of Wolf Lake, particularly the North Inlet. Their arrival on the spawning areas was closely correlated with the temperature of the water in the streams. They never appeared until the dwarf suckers had reached the peak of their spawning activities and were beginning the return journey to the lake. The dace maximum population occurred at the termination of the sucker spawning season.

The horned dace constructed their nests well downstream mostly below the spawning areas of the dwarf sucker. Although there was a slight overlapping of spawning grounds the two species seemed to carry on their particular activities without conflicts or interference of any kind. When the breeding season is over the dace may avail themselves of the supply of sucker eggs and newly hatched fry. The latter should be especially attractive; coming at a time when the dace are about to resume normal feeding habits.

PARASITES

The following data on host-parasite relationships were obtained in conjunction with, and coincidental to, other studies on breeding dwarf suckers. They seem to have sufficient importance to warrant inclusion in this report and may be contributions to the knowledge on the life histories of the parasites involved. It should be stated at the outset that, in general, dwarf suckers appear to be experiencing a relatively healthy existence in the lakes on the Forest. The very fact that so many individuals were capable of successfully completing the spawning functions for several years in succession, despite the possible handicap from the loss of one or more fins is quite indicative.

In the 1938 spawning season several dwarf suckers were found at Wolf Lake that were harboring *Philometra nodulosa* Thomas in the connective tissues of the cheeks and lips, particularly the cheeks. Several of the hosts carrying this nematode were preserved for future study. Strange as it may appear, scarcely any evidence of further infestation from this worm was observed at Wolf Lake in subsequent years, although each fish was examined superficially in that respect.

While studying a collection of common suckers obtained June 2, 1943 from the spawning grounds in a tributary of Arbutus Lake, the writer was surprised to find a rather high incidence of infection of *Philometra* in the connective tissues of the pectoral fins. Five of the twenty-one suckers in the collection were infected and two or more worms were found on each fish, either on one or both pectorals. The same condition likewise prevailed in subsequent years. These *Philometra* have not been identified to species. They appear to be different from *P. nodulosa*. The worms usually occupied the upper thicker portion of the fins utilizing the tissues between two or more adjacent fin rays. Whenever the space between a pair of fin rays became inadequate for the worm it made an abrupt crossing to the adjacent space and thence moved in a diametrically opposite direction.

The cheeks and lips of every dwarf sucker in the Arbutus Lake collection were carefully studied, but there was no evidence of infestation either in the lips or pectoral fins. Possibly this may be the first record of its appearance in the pectoral fins of any species of sucker, because the writer was unable to find any published account of its occurrence other than in the cheeks and lips. One of the worms was dissected, and its uterus was observed to be well filled with developed larvae.

During the 1940 dwarf sucker spawning season a good many cestodes of the family caryophyllaeidae (*Glaridacris catostomi* copper) were found in the bottom sediment of the retaining pails after batches of fish had been confined for a considerable time (about one-half hour on the average). Practically every batch of fifty or a hundred yielded a dozen or so cestodes in this manner. This phenomenon never was observed during other years under similar circumstances, and the application of the same techniques. The worms were not eliminated while the fish were struggling in the hands of the writer during the period they were being subjected to various treatments including the amputation of fins. Possibly reduction of the oxygen supply to near exhaustion as the result of retaining the fish in such limited confines may have been a contributory factor in causing this to occur. Sometimes the fish were retained until they began gulping air from the surface or became prostrate. While this treatment never was fatal to the host it may have stimulated the parasites to leave the intestinal tract. The appearance of this cestode in this manner during a single session suggests that it may have been scarce at other times. The preserved worms average about 25 mm. in length.

Ligula intestinalis Linnaeus occurs in great numbers in the common shiners, *Notropis cornutus frontalis* (Agassiz), of Wolf Lake, but the dwarf suckers for some reason support few of these worms, which seems contrary to what might be expected—usually members of the sucker group are quite vulernable to attacks by ligulas.

Diphyllobothriidae of the genus *Schistocephalus* also occur in Wolf Lake, but they have been observed only in the sculpin, *Cottus cognatus* Richardson, captured on the dwarf sucker spawning riffles.

Some of the dwarf suckers collected in Wolf Lake during July, 1941 were heavily infested with Acanthocephala, *Pomphorhynchus bulbocolli* Linkins. Most members of the sucker family are highly susceptible to this parasite; therefore its presence in dwarf suckers is in no sense unusual.

Five leeches, *Placobdella parasitica* (Say)*, were found attached to the inside of the gill cover of three landlocked dwarf suckers captured in Arbutus Lake inlet on July 4, 1944. A considerable number of other leeches, *Macrobdella decora* (Say)*, occurred in the same habitat, but these did not molest the dwarf suckers, seemingly preferring black-nosed dace in the association instead.

* Identified by Dr. Raymond Myers, Colgate University, Hamilton, N. Y.

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